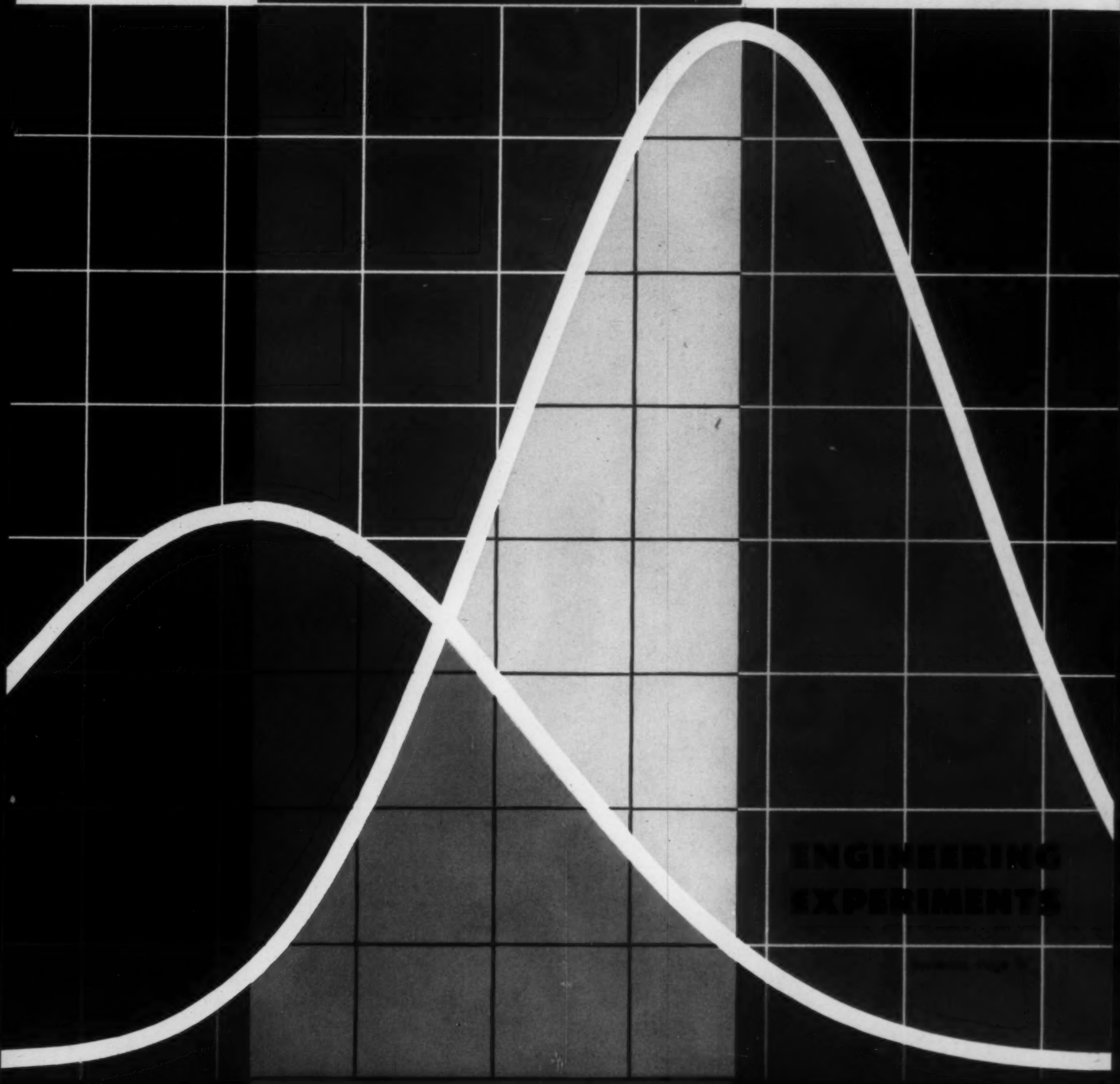
JUNE 11, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



ENGINEERING EXPERIMENTS

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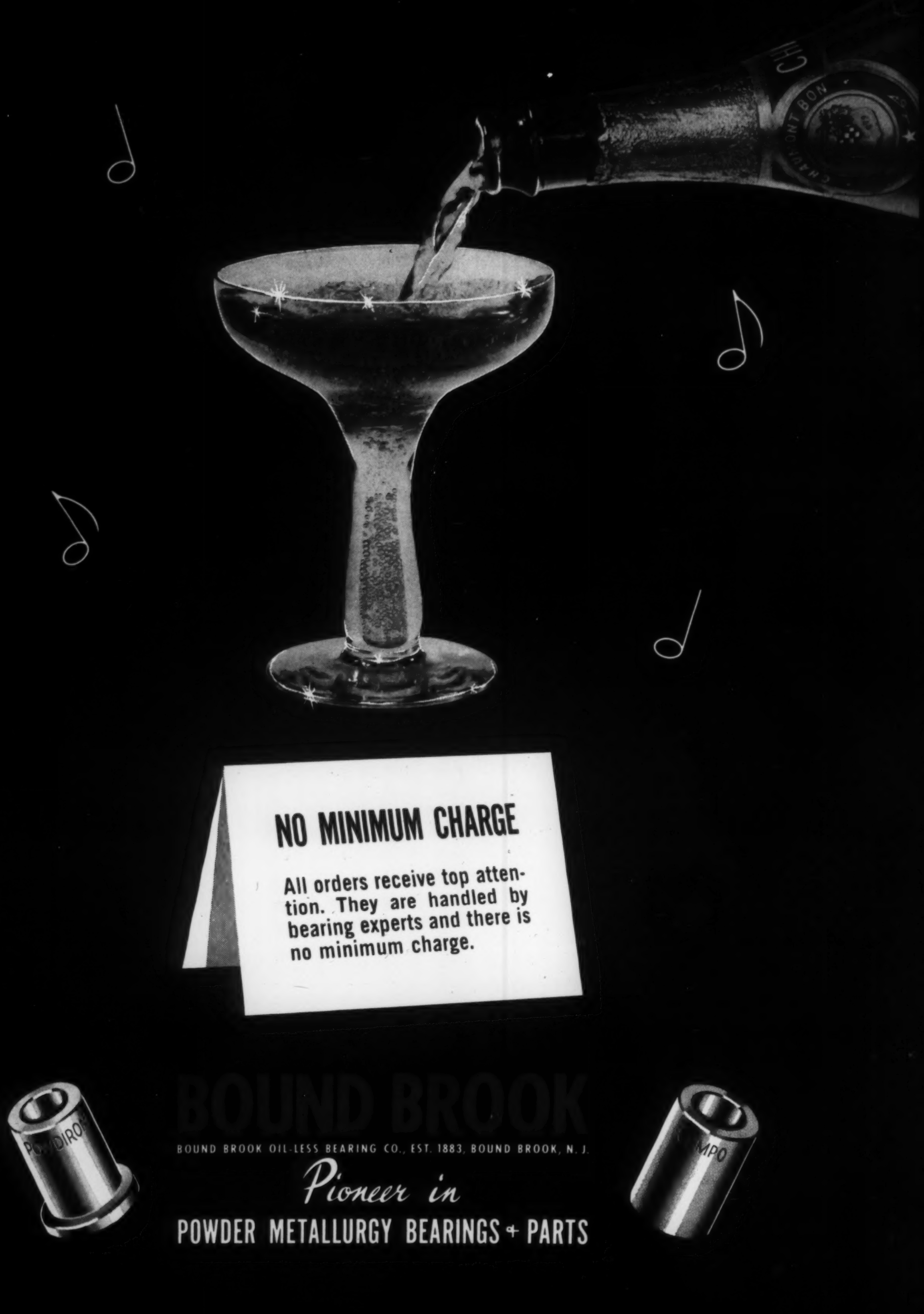

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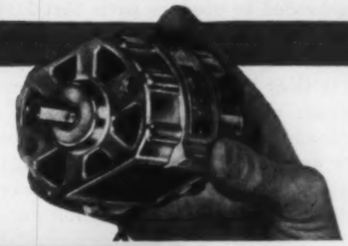

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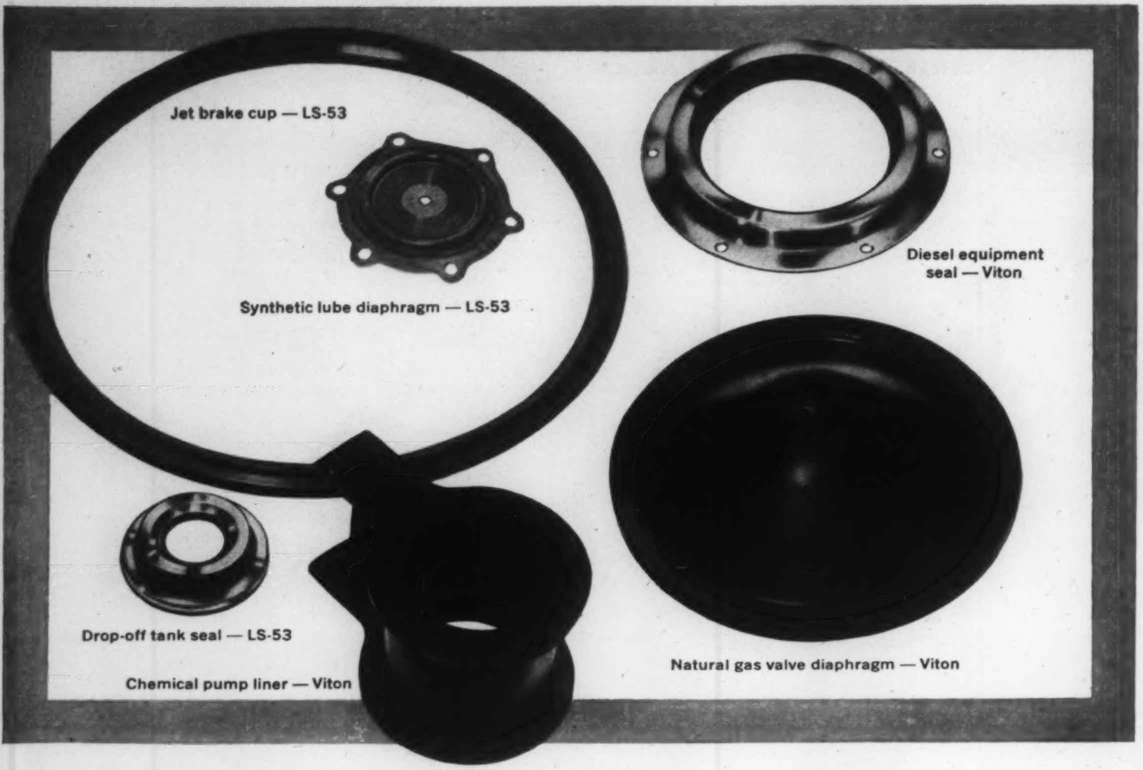
Jet brake cup — LS-53
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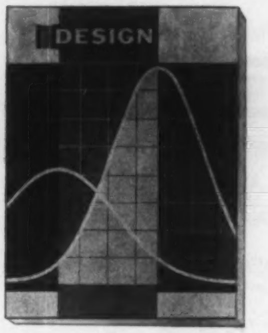

Front Cover: Statistical techniques offer a logical approach to setting up and analyzing experiments. One method, as shown on George Farnsworth's front-cover design, is to compare two sets of data (normal curves) by "measuring" the difference between their means. Article by Bill Hyzer on Page 134 tells how to get meaningful comparisons.

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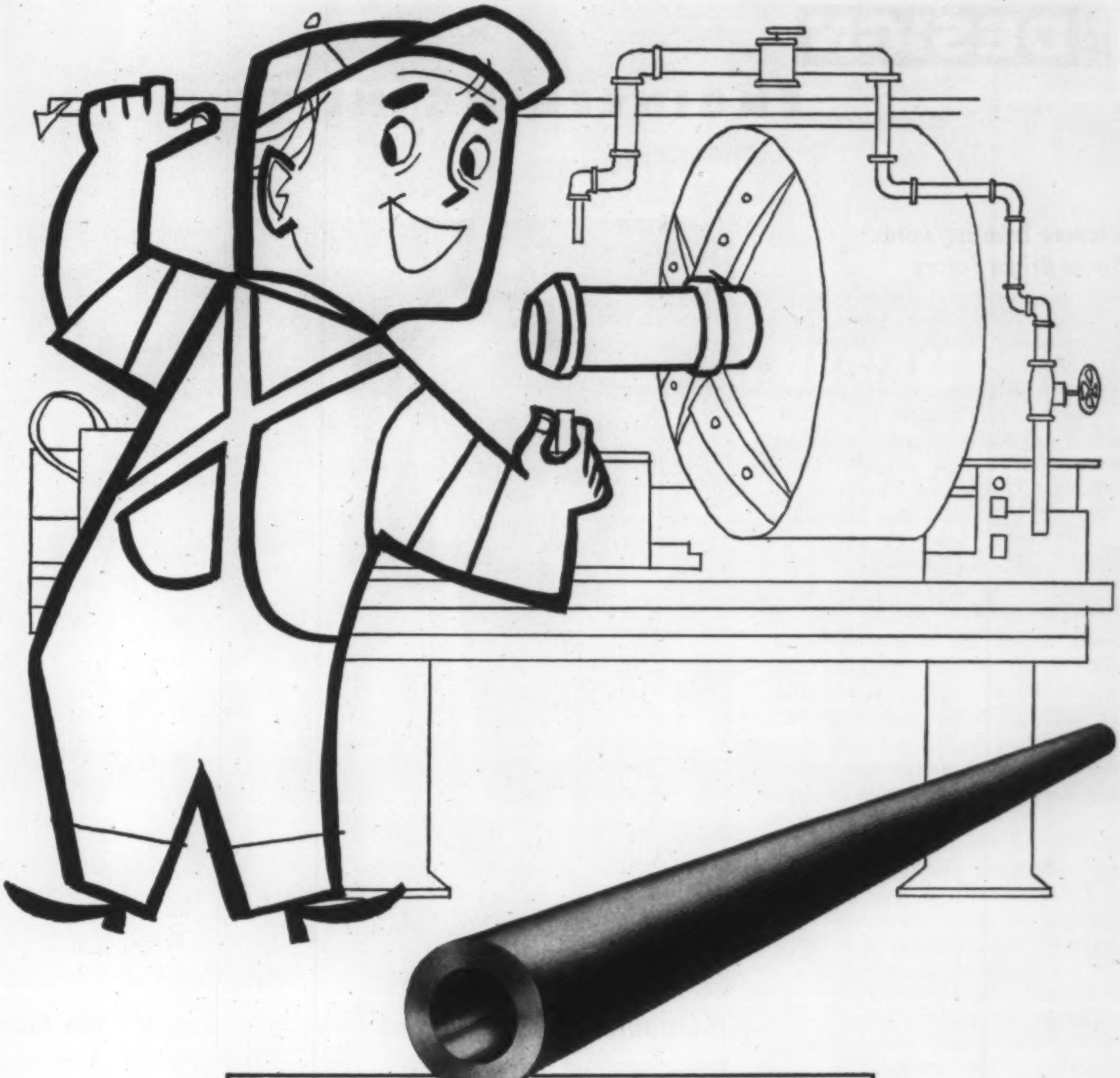

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MACHINE DESIGN

ENGINEERING NEWS

Chrome Trim for Autos Faces Bright Future

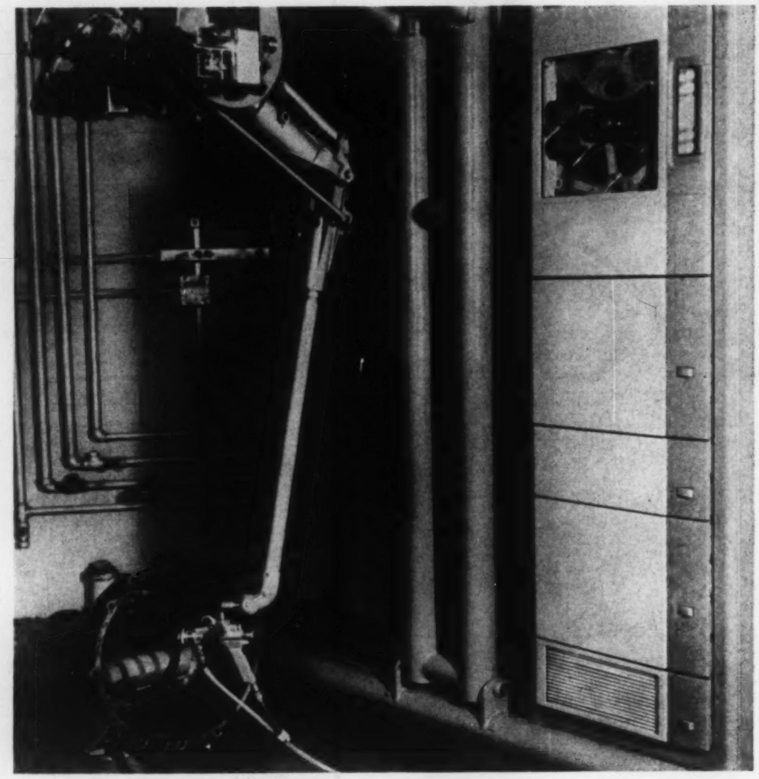
New Plating Process Gives Ten Times Thicker Chrome

DETROIT—Rust spots on chrome-plated bumpers and other automotive trim will be fewer in the future because of a new chrome-plating process. The process, developed by Metal & Thermit Corp., applies a much thicker layer of chromium than ever before possible.

"Accelerated laboratory tests demonstrate this new process can add years to the life of chrome-plated trim on automobiles, even in areas where the atmosphere is regarded as highly corrosive," says H. D. McLeese, Metal & Thermit vice president. "Several automobile manufacturers have started using this new method to chrome plate bumpers, grille work and other exterior trim, and others are planning to use it."

Until recently it has not been possible to plate chromium commercially much thicker than 10 to 20 millionths of an inch. Whenever thicker coats were applied, internal stresses built up rapidly within the coating and caused excessive cracking. This produced a rapid reduction in corrosion resistance.

"The new process consists of the successive application of two different types of bright chrome plate. The first provides especially good covering and throwing power to plate more uniformly even in hard-to-reach recesses; the second builds up the total thickness of chromium to as much as 100 to 200 millionths of an inch—or approximately 10 times what previously was specified," according to McLeese. Further, "it has proved that it can be adapted to most existing production plating operations with minor modifications. For some applications, it may be possible to use thinner undercoats of copper and nickel, indicating actual potential cost savings over previous practice."



Manipulator with Memory Has Better Recall Than Man

Tape programmed manipulator repeats jobs with uncanny accuracy after being "shown" once. Two arms can be controlled from a single magnetic tape where needed, since neither would use more than half of the 14 tracks available. Borg-Warner's servo-controlled manipulator is used to replace human operators in dangerous or uncomfortable environments, where automatic repetition of outlined tasks leads to economy, or where degree of accuracy required in a complex repetition is beyond the range of human skill. Ampex FR-100 recorder holds errors in a 6-ft excursion to 1/4 in. In the application shown, interior of a cast housing is being spray painted by the manipulator.

Trend-Happy Designers May Be Replaced by Electronics

LONDON, ENGLAND — The designer may soon be replaced by the electronic computer, said American industrial designer Henry Dreyfuss at London's Royal College of Art. "The world's mass-produced goods look so much alike that they might just as well be designed by machine.

"We've become trend-happy. Great regional design traditions, like those of Scandinavia and the Orient, suddenly become worldwide fashions. The epidemic rapidly spreads to designers in every industrial center. Overnight, skilled designers in a dozen countries are turning out watered-down Danish furniture, Swedish stainless ware, Japanese interiors, and Thai fabrics.

"There's nothing wrong with designers exchanging ideas. But too

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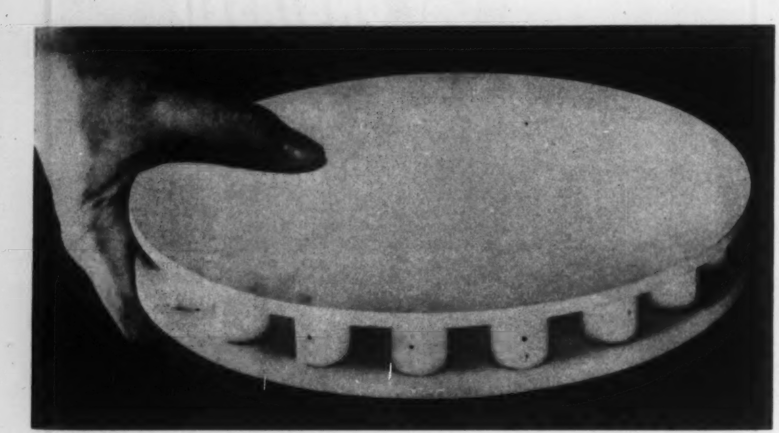
often we act like a classroom full of school-kids copying each others' examination essays. A good student learns all he can from his teachers and friends, but at exam time he comes up with his own answers."

American designers must take their share of the blame, admitted Dreyfuss, whose work has ranged from telephones to airliners. "The influence of our housewares and appliances has often been a healthy one. But what of the fins that are beginning to sprout on European cars? What of the 'wicker' baskets that European factories are stamping out of pink plastic?"

Even the Russians are climbing onto the bandwagon. According to Dreyfuss, "A Soviet factory is now making a carbon copy of a washing machine we designed for a British manufacturer a decade ago."



Heat-Resistant Mirror Reflects Space-Age Demands

Rapidly changing temperatures and stresses of rocket flight into space won't change the resolving characteristics of this telescope mirror. Body of the mirror is made of Pyroceram, developed at Corning Glass Works, Corning, N. Y. It has practically zero coeffiicient of thermal expansion from −100 to +150 F, the range in which the telescope is expected to operate during flight in a space vehicle. Novel truss-like construction, with two thin discs of Pyroceram held apart by short tubes of the same material, combines rigidity, light weight, and ability to achieve steady state quickly after a drastic change in temperature.

First Nuclear Aircraft May Be Giant Blimp, Says Goodyear

Ship of Unlimited Range Can Be Available in 1963

AKRON — A nuclear blimp, three times the size of present-day nonrigids, can be built to meet Navy requirements by 1963, says Goodyear Aircraft Corp. Operating at 10,000 ft, the ship could travel at 70-80 knots for practically unlimited range. Its 540-ft hull would locate the reactor far enough from the control car to give the crew a radiation environment similar to that in an atomic plant. Goodyear says the ship could be operational by 1963.

Dacron cloth coated with synthetic rubber would cover the 4.5 million cubic foot body of the airship. The new material can withstand 10^8 roentgens of radiation and has aging and diffusion characteristics equal to those of present coatings.

Plans call for an 86-ft, two-deck control car accommodating a crew of 24. The reactor located amidships will power turboprop engines during flight. Chemical fuel will be used for take-offs and landings. Radiation will be at a low level, so very little special protection for ground crews will be needed. The nuclear powerplant will be 1/20 of the size needed for a heavier-than-air craft.

Topics

Plastic "woods" may take strokes off a golfer's score. Molded from a tough plastic, a golf-club head produced in England has the same feel and produces the same click when it meets the ball as a wooden club, but its shape is unaffected by moisture. Tests have proved that moisture absorbed from the air causes distortion, changing the face angle of a wooden golf-club head. One degree of misalignment can put a perfectly stroked ball off 40 feet in a 225-yard drive.

• • •

No color seems to be preferred by 1959 auto owners, according to statistics from Dodge. For the third year, white—either as a single-tone "color" or in two-tone combinations—has been most popular with Dodge buyers. Color preference is a regional affair: Next to white, Westerners like beige best, while more conservative Eastern and Midwestern buyers choose black.

• • •

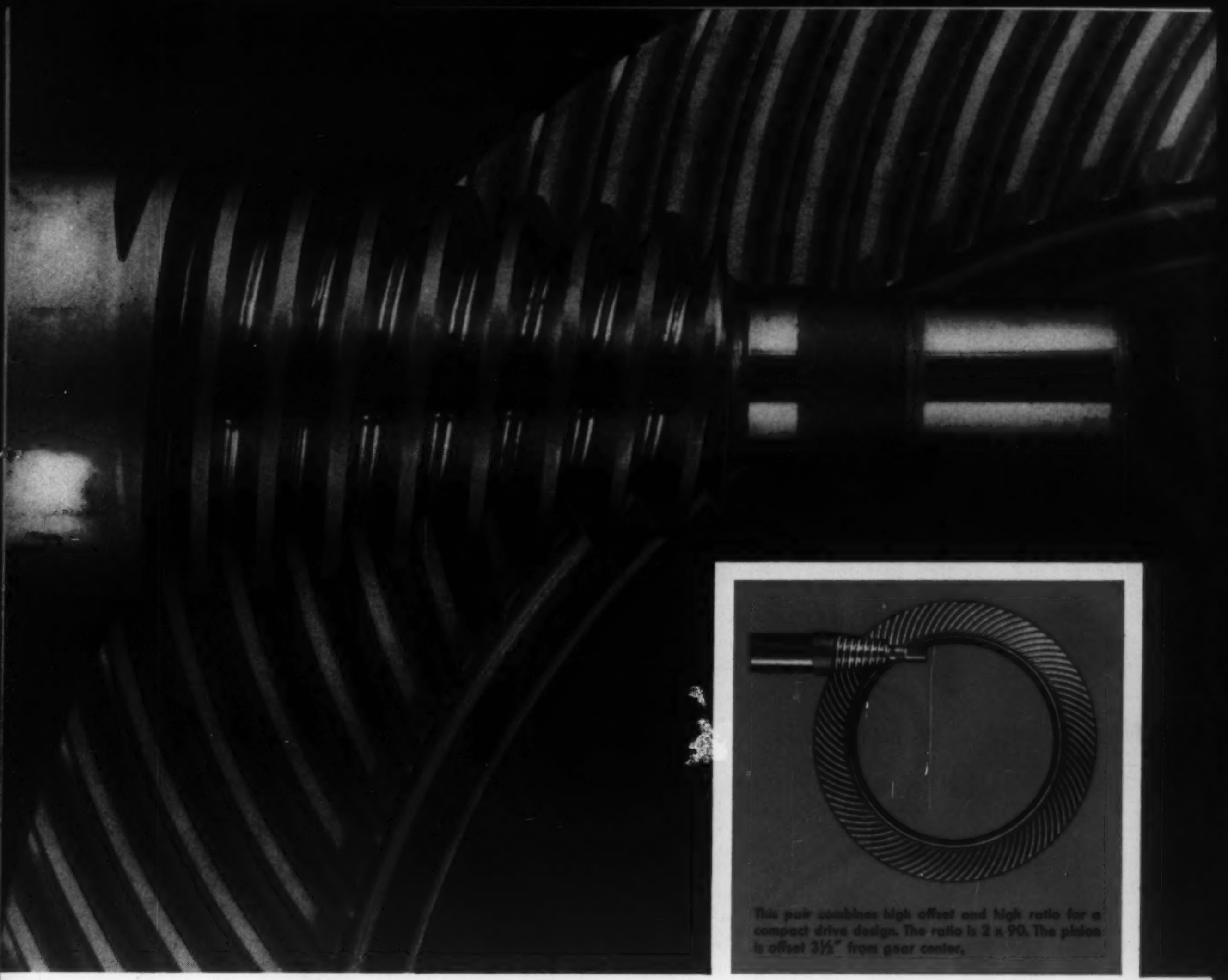
Underwater space travel may provide a solution to the problems caused by effects of acceleration on the human body. At the Naval Aviation Medical Acceleration Laboratory, Johnsville, Pa., personnel wearing oxygen masks and swim suits have been taking "trips" in an aluminum container called an Iron Maiden. The device, which holds one man, is filled with 95-deg water and attached to a centrifuge. Acceleration forces up to 31 g have been attained, without adverse effects on the subjects' hearts and circulatory systems, and without a resulting feeling of fatigue.

• • •

Buoy reporter for the Navy, a 60-lb aluminum and plastic structure, gathers oceanic data and radios information to nearby vessels where it is tape-recorded for later analysis on electronic computers. The radio will transmit for 8 hours and has a range of 11 nautical miles. Signals are sent on a 7-ft, five-pronged upright antenna, which gives the buoy a slightly satellite-like appearance and accounts for its name of Splashnik. Previously, measurements of ocean waves were made on shipboard devices or costly conventional buoys. Neither method was nearly as satisfactory as the $125 Splashnik.

• • •

Electronic billy, for night watchmen and plant guards, has a concealed button which, when pressed, sets off the building's burglar alarm. Installation of this warning system, made by Multitone Electric Co. Ltd., England, requires only a thin wire running around the outer walls of the building.



This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid* straddle mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset *or* high-ratio pairs, the "wrap around" tooth design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS
1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

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NFPA Agrees on Cylinder and Rod Sizes

ASHEVILLE, N. C.—Specification and procurement of hydraulic and pneumatic cylinders move to a more rational basis following recent action by the National Fluid Power Association. At its Annual Meeting on May 18, the Association adopted suggested series of bore diameters and piston-rod diameters. NFPA action, in effect, constitutes a preferred-size recommendation to designers and users of cylinders.

Agreement on suggested sizes followed an extensive survey of more than 300 cylinder manufacturers. Over 100 companies contributed data indicating preferences for cylinder and rod diameters in future designs. Before adoption by NFPA, both series were refined and aligned with American Standard Preferred Numbers.

Suggested Bore Diameters (in.)

1	2½	4½	10
1⅛	3	5	12
1¼	3¼	6	14
1½	3½	7	16
2	4	8	20

Suggested Rod Diameters (in.)

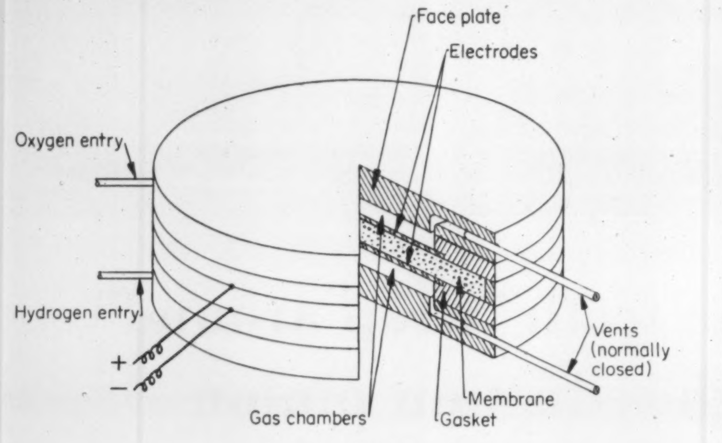
5/16	1	2¼	5
3/8	1⅛	2½	5½
1/2	1¼	2¾	6
5/8	1⅜	3	7
11/16	1½	3½	8
3/4	1¾	4	9
7/8	2	4½	10

In tune with the ASA Preferred Number philosophy—i.e., maximum design choice with minimum practical number of size increments—the NFPA suggested series contain only about 25 per cent of cylinder and rod diameters now in use.

Magnetic Mount for Cup Packing

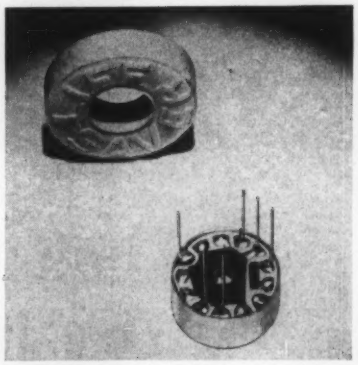
Self-centering compensation for out-of-round cylinders is provided by a magnetic mount for hydraulic or pneumatic piston cup packings. Developed by E. F. Houghton & Co., Philadelphia, the mount uses a tiny magnet for holding power. The magnet is located within a magnetic follower plate. The shoulder of the plate contacts the plane face of the piston through the center hole of the cup packing. Other advantages claimed for this type of mounting include ease and economy of installation, provision for the packing to breathe, and elimination of cup-bottom squeezing through overtightening.

New Progress in Fuel Cells



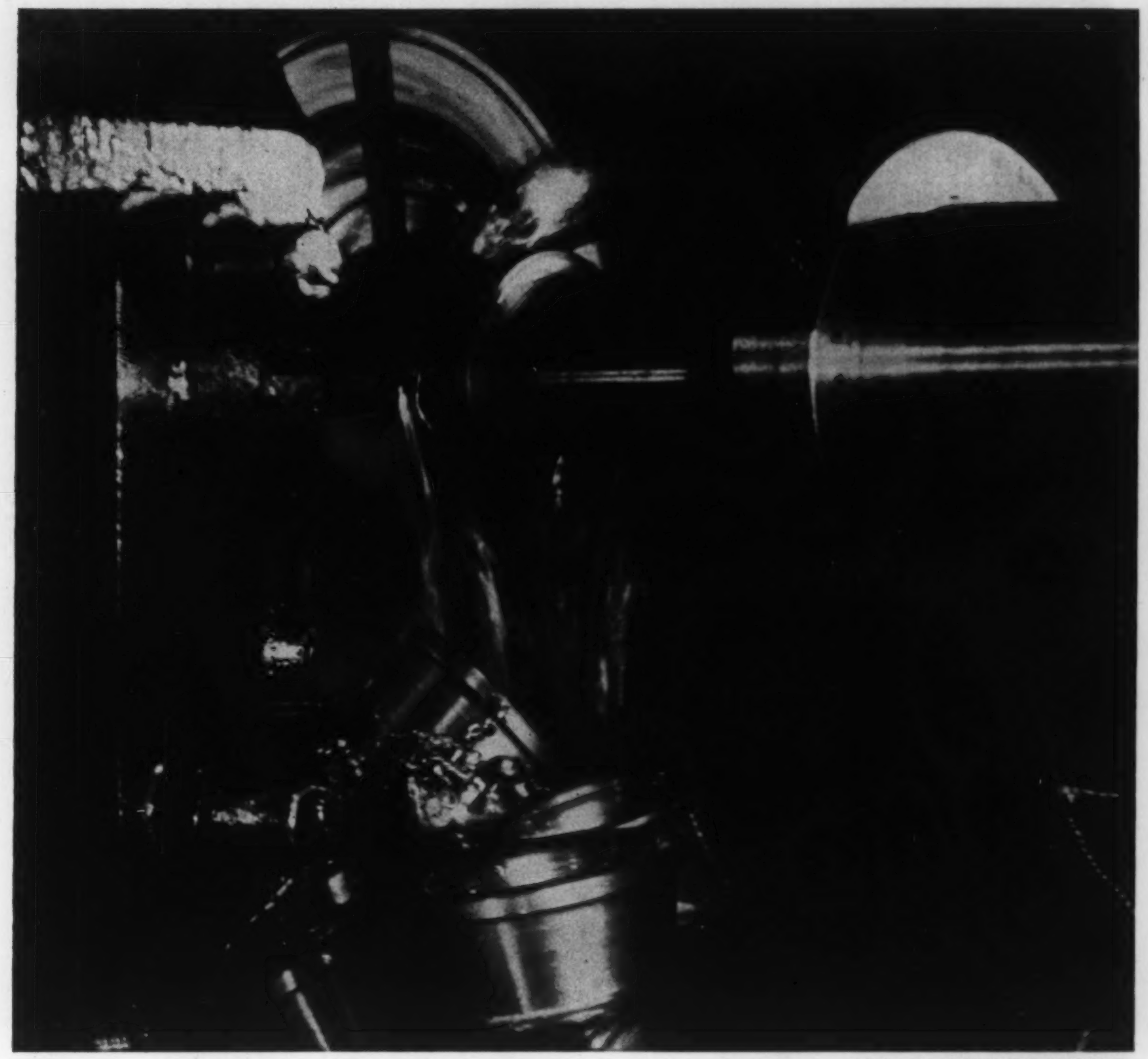
Cell Structure

Fuel cells with ion exchange membrane electrolytes are reported practical by General Electric. These new cells solve problems of ion leakage, water collection at fuel electrode, and electrolyte dilution. In GE working models, hydrogen is fed into one chamber and oxygen into another. Hydrogen ions pass through the membrane to the oxidant electrode where water is formed. Electrons from the fuel electrode arrive via the external electric circuit. More than 60 per cent of heat released by combustion is converted to electricity. Power densities as high as 2 kw per cu ft are predicted.



High Gain in Space

Complete four-stage amplifier with a gain of 72 db is included in this 1/16-oz package. The hermetically sealed case, ½ in. diam by ¼ in. thick, contains 12 resistors, 5 capacitors, and 4 transistors. Centralab, Milwaukee, developer, says that with 1000 cps as a base, the amplifier has a roll-off of 2 to 5 db at 3000 cps. At 300 cps, response is down 3 to 6 db. Load impedance is 1000 ohms inductive load; 400 ohms max dc resistance. Designed to operate with a 1.34-v mercury cell, the TA-12 draws from 1.6 to 2.2 ma. As a weight and space-saving unit, it will be used in missiles, hearing aids, and computers. Nominal input impedance of the amplifier is 2000 ohms.



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All-Plastic Interiors—Next in Auto Design?

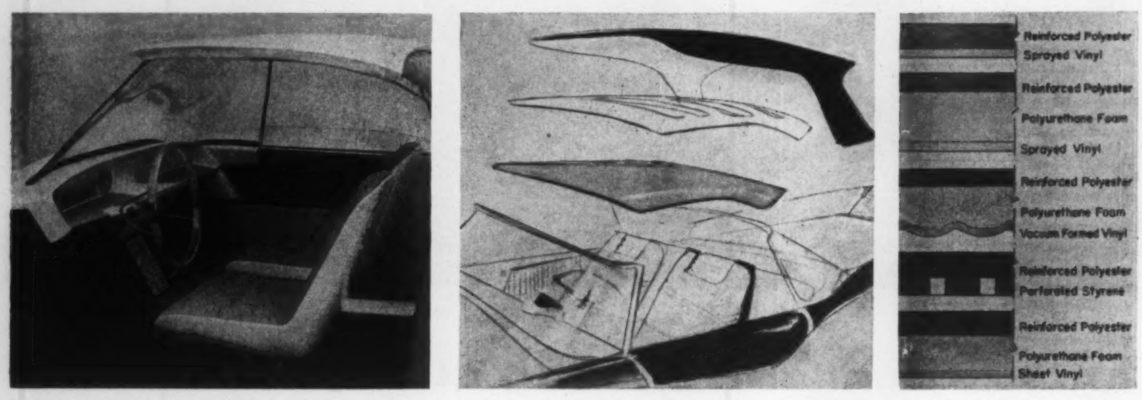
Uses Are Promising, But Techniques Lag, Says Ferrar

FIGHTING for the competitive edge in the automobile market, manufacturers are tending to eliminate the minor face lift from year to year and to come out instead, with a brand new shape. This means higher tooling and production costs, and can mean telescoping of lead time. To solve both of these problems, a leading plastics manufacturer and a prominent industrial designer recommend the use of more plastics in cars.

Monsanto Chemical Co. has completed an elaborate design and research report and has come up with the "molded interior concept" for cars. The firm's Plastics Div. at Springfield, Mass., has followed through with a completely molded auto interior. The mock-up takes advantage of the inherent properties of plastics for variety of form, color, texture, and ease of installation. It also shows the savings in labor offered by plastic components. Seats, for example, instead of being assembled from a number of subassemblies, are completely molded, with cushioning and upholstery integral with the shell. In actual production, seats would come from the molder ready for installation, eliminating the need for all but minor seat-assembly labor. Floor covering, door liners, instrument panel, and roof are also plastic; all are easily installed.

Biggest obstacle to immediate adoption of these and other plastic components in cars is cited by Montgomery Ferrar, Detroit industrial designer. According to Ferrar, "The plastics industry has a long way to go to catch up with the advanced techniques that are today taken for granted by the metalworking industry . . . So long as we are confined to compression and injection-molding techniques as we know them today, there is going to be a definite ceiling on the amount of plastics poundage used in automobiles. Why, for example, can't we have a fully automated process which would permit a material like Pro-fax to be converted by an extruder into sheets and moved down the line in one operation to be formed into a trunk lid, complete with hinge—a unitized part that would require no subsequent finishing and would remain like new during the life of the car?

"Plastics combined with other materials could conceivably replace metals for door handles, grilles, and other hardware; and metalized plastics that would never dull, corrode, or scratch offer a number of advantages over chrome for a car's bright work. In the same manner, a marriage of plastics with some other material could produce floor boards with a corrosion-resistant underside and a carpeted upper surface resistant to stains and abuse."



Molded seats and roof are two of many plastic components proposed by Monsanto Chemical Co. to cut lead time and costs in automobile production. Seat's cushioning and upholstery are integral with the shell, permitting fast, labor-saving installation. Roof has a hard exterior, center layer of foam insulation, and textured, decorative interior. Possible combinations of roof materials are shown at right. Although initial cost of plastic components might be higher than materials now used, this might be offset by big savings in on-the-line installation time.

Overtime Pay for Salaried Employees Surveyed

Number of companies reporting . . .	Type of Manager				
	Factory	Clerical	Salaried Professional	Middle Management	Top Management
straight time	84	57	53	23	0
time and one-half	50	44	38	17	0
sliding scale	20	19	19	11	*a*
time off	4	6	7	5	4
other	41	31	31	21	6
Total	199	157	148	77	10

a—Implied by several of the ten companies reporting.

Fifty-two per cent of American companies pay managers and supervisors for overtime work. In an American Management Association survey, 224 of 434 responding companies report compensation for employees exempt from compulsory overtime pay provisions of the Fair Labor Standards Act. Further, 216 companies report in detail what types of exempt employees are compensated and what compensation methods are used. These data are summarized in the table, left. In the sliding scale method, the percentage of hourly pay is less for the higher paid employees. Another fact turned up—large companies are more likely to pay overtime than are small companies.

TORRINGTON

Torrington Needle Bearings are available for shafts up to 7¼" in diameter. Full complement of rollers provides highest radial capacity for a given cross section. They offer low unit cost, compactness and light weight and long service life. They take a press fit in a simple straight-bore housing, run directly on hardened shafts, permitting use of larger and stiffer shafts.

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These advantages have been proved in performance in tractor bolsters, transmissions and final drives. In haybaler crank shafts. In power shovels. In heavy duty hydraulic pumps and starting motors. In road wheel arms on tanks. Why not talk over *your* application with your Torrington representative? **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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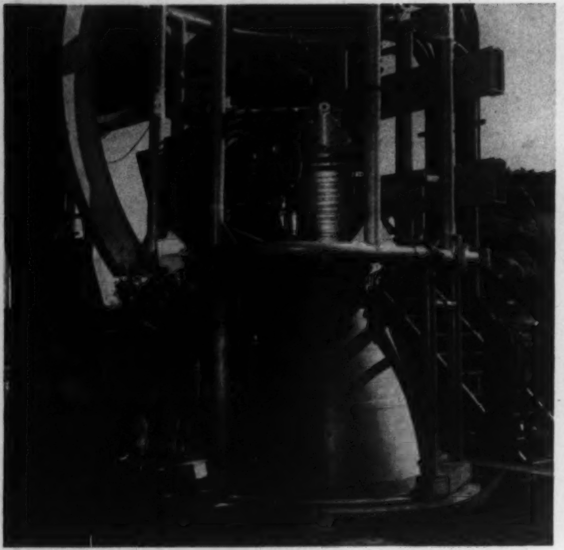
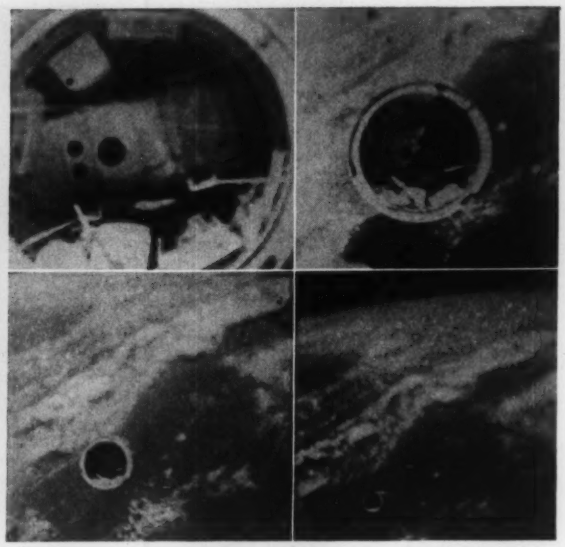


Million-Pound Kickoff

Fired in clusters of eight, liquid-propellant rocket engines like this will develop 1,500,000-lb thrust in the first stage of ARPA Project Saturn. Army Ballistic Missile Agency will build and test the cluster at Huntsville, Alabama. First engine has been delivered to Redstone Arsenal by North American Aviation Inc. The Saturn first-stage system will be four times as powerful as any other flight-tested American system. Design is based on Thor and Jupiter models.



End of the Ride

Power section drops away from a Jupiter IRBM nose cone 125 mi above the earth's surface. Pictures are part of series taken by a 16-mm ACR Electronics Corp. camera as the nose cone coasted up to a 300-mi-high apogee. GE-designed data capsule, carrying the camera, was ejected shortly before impact and was recovered 39 min after launching, 1400 mi downrange. Purpose of the pictures is to verify nose-cone separation characteristics.

Separating the Men From the Space-Men

To gage abilities of Project Mercury applicants (the man-in-orbit project), NASA subjected each man to a battery of tests. Here are typical questions. How well do you score as a potential space man? NASA's answers are listed on Page 27.

Analogies Test

Sample—LIGHT : DARK : : PLEASURE : (*a*, picnic; *b*, day; c, pain; *d*, night) Read "LIGHT is to DARK as PLEASURE is to WHAT?" Answer: c, pain.

1. LAUGH : (*a*, joke; *b*, cry; c, grin; *d*, humor) : : JOY : SORROW
2. RECOVER : (*a*, bottle; *b*, correct; c, rescind; *d*, renew) : : RECOUP : RECTIFY
3. FICTION : (*a*, memory; *b*, fact; c, novel; *d*, imagination) : : AUTOBIOGRAPHY : RECALL
4. REDUNDANT : REPETITIOUS : : (*a*, non sequitur; *b*, false premise; c, recurrence; *d*, precondition) : FALSE CONCLUSION
5. BRASS : ALLOY : : IRON : (*a*, compound; *b*, element; c, steel; *d*, rust)
6. CONDUCTANCE : RESISTANCE : : MULTIPLY : (*a*, integrate; *b*, magnify; c, divide; *d*, differentiate)
7. BODY : PHYSIOLOGY : : TRIANGLE : (*a*, astronomy; *b*, algebra; c, calculus; *d*, trigonometry)
8. VACUUM TUBE : THYRATRON : : CONTINUOUS : (*a*, alternating; *b*, regular; c, discrete; *d*, diminishing)

Mathematical Reasoning

Directions: Each of the following problems consists of five mathematical figures or expressions. Four of these have something in common which is not shared by the remaining one. Choose the one figure or expression which does not belong with the other four and show your choice by underlining it.

Sample—(A) 1, (B) 2, (C) 3, (D) 4, (E) 107—Answer: Underline (E) 107

9. (A) 15, (B) 25, (C) 125, (D) 317, (E) 625
10. (A) circle, (B) ellipse, (C) parabola, (D) square, (E) triangle
11. (A) 7:49, (B) 6:36, (C) 5:25, (D) 4:16, (E) 3:12
12. (A) $x + y = 12$, (B) $2y = 2x + 5$, (C) $3y = 7 - 3x$, (D) $5y + 5x = 9$, (E) $4x = 5 - 4y$

Metallic-Fluoride Film Found Excellent Insulator

NEW YORK—Fluoride coatings can be formed on copper, aluminum, and other metal wires to provide exceptionally high electrical insulation, even at elevated temperatures. The insulating films are both flexible and free from porosity.

Insulating coatings are formed directly on freshly cleaned copper or aluminum by hydrogen fluoride or elemental fluorine, for example, at temperatures of 300 to 600 C. The thickness of the resulting copper and aluminum-fluoride films depends on temperature, fluorine concentration, and exposure time. Aluminum forms a fluoride film one micron thick in a few minutes at 550 C. Films remain adherent when bent repeatedly at right angles.

Electrical insulation values are very high, about 10^{10} and 10^{11} ohms at room temperature for films 1 to 2 microns thick. Aluminum-fluoride films exhibit resistances of about 7 x 10^8 ohms at temperatures as high as 500 C. Copper-fluoride film resistance is comparable.

The aluminum-fluoride films show excellent resistance to oxidation even above 600 C. They also show no tendency to hydrate or dissolve on exposure to high humidity. The insulation does not break down even at 450 v at 500 C.

Discovery of the new insulation is credited to Drs. S. S. Flascher and P. D. Garn, Bell Telephone Laboratories, New York.

Angle Block Floats on Air

Air lifted granite angle block can be guided into position with a mere touch of a finger. Designed by Herman Stone Co., Dayton, Ohio, the block floats on a cushion of air while being moved from one position to another. Air is piped into the back of the block and fed to a series of grooves on the bottom surface. Grooves are located so that the air will escape if the block is moved too close to the edge of the surface plate, thereby preventing the block from "floating off" the edge.

Spray Painter Atomizes Paint Electronically

ROCKVILLE, MD.—New commercial paint-spraying equipment discards compressed air as a carrier of paint materials. Instead, it uses a hydrocarbon (chemosene) atomized by an electronic heating element within the unit. No mechanical parts are involved, and operation is reported noiseless.

Developed and patented in Holland, the unit is manufactured in the U. S. by Lofstrand Co., Rockville, Md.

Advantages claimed for the new technique include less spray mist and consequent reduction in paint-shop health problems, higher concentration of solids in the paint spray resulting in fewer coats of paint needed, and reduced influence of temperature and humidity on the quality of the paint job.

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Here is a powerful, compact, variable speed drive in 20 and 25 h.p. ratings, offering—

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3:1 speed range.

Constant torque characteristics plus 1.4 service factor.

Selection of Companion Sheaves for wide choice of operating speeds.

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
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430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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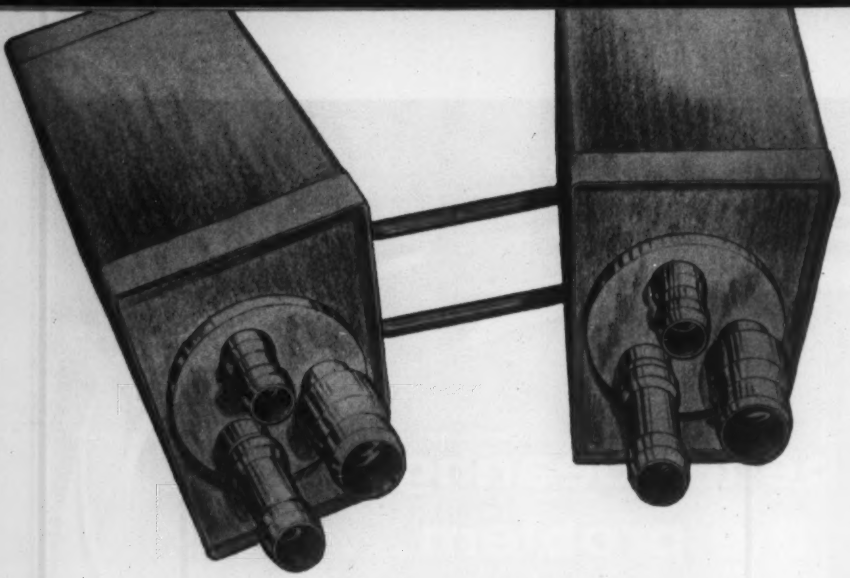


Stereo TV

Born in atomic hot labs, 3-D television is already in advanced development. Further refinements will make it feasible for industry and home viewing.

AIDED by recent research, TV has succeeded in transmitting the impression of depth by borrowing some tricks from the old parlor stereoscope. Atomic research sparked the study but, with further development, new uses may be found in research, industry, education, and entertainment.

Here's the progress to date on three different approaches. Not all of the problems have been licked, but workable models of the three systems have been built. Developers are confident that trouble-free stereo TV is only a matter of time.

Stereo Statistics

Depth is perceived because the eyes focus, converge, and record slightly different images for comparison. The brain automatically relates focus, convergence, and the difference between the images to form a conclusion about relative depth, and records a three-dimensional picture consistent with its findings.

Stereophotography takes a pair of pictures from slightly different angles to represent two eye images. It is the job of the stereoscope, 3-D movie, or stereo-television to present one of the images to each eye. The fewer the contradictory pieces of evidence the brain receives, the less tiring the process will be.

Design Considerations

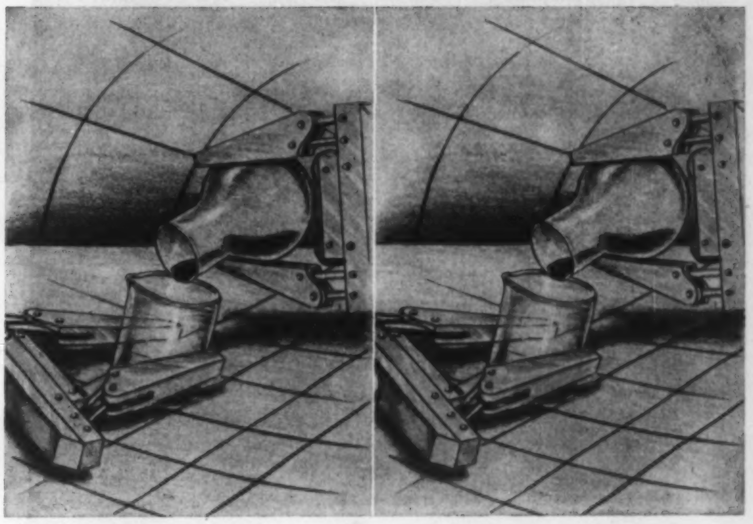
To look at a point 18 in. away, the eyes converge nearly 10 degrees. To look at a point a mile away, they converge only $3\frac{1}{2}$ minutes. Many viewing systems are arranged to cause about 10-degree convergence of the eyes. To converge 10 degrees on a 1-mile point, cameras would have to be spaced about 1000 ft apart. Obviously, convergence cannot be completely compensated, but many good stereo systems do have provision for adjusting distance between camera lenses. Others have lenses permanently set at a distance that will give best results in anticipated viewing conditions.

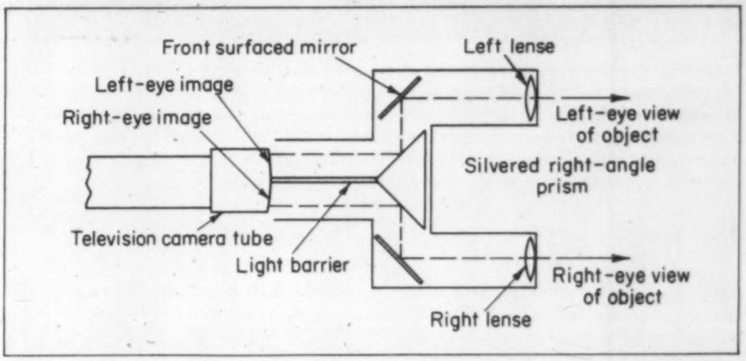
By far the most important feature of the stereo system is the image itself. By comparing slightly different perspectives in two different images the brain does 70 per cent of its work in depth perception. It follows that perspective in stereo images should not be distorted. Perspective is a function of the solid angle, with its apex at the eye, that is covered by the image. A 5-ft-high object photographed at a distance of 10 ft will appear at its best perspective in a picture 18 in. from the eye, if the image of the object in the picture is 9 in. tall. That is: $5:10 = 9:18$.

In perspective some compromises must be made. Not all objects—near and far—in a scene can appear in their best perspective. In a good stereo system, much thought has to be given to viewing distance versus camera-to-subject distance, and proper image size.

Here's the Hardware

The most ticklish solution concerns the problem of presenting one image to each eye without the



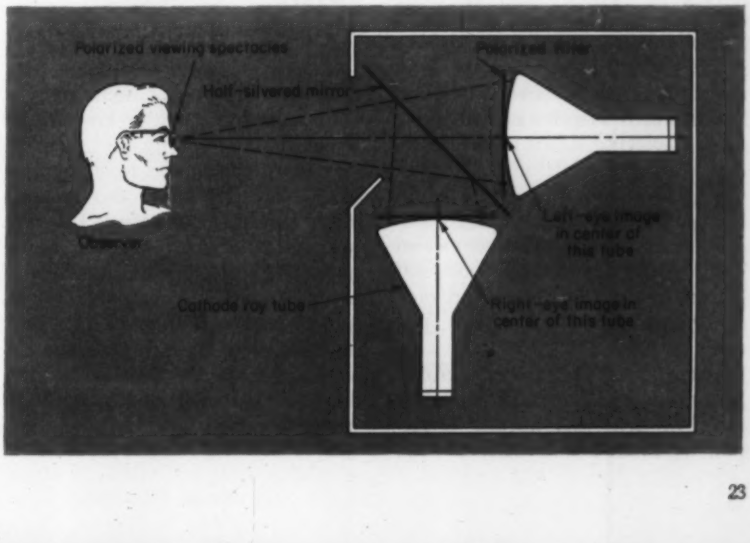

Front surfaced mirror
Left lense
Left-eye image
Right-eye image
Left-eye view of object
Silvered right-angle prism
Television camera tube
Light barrier
Right-eye view of object
Right lense

Early system used one TV chain. Prism directs left and right eye images to opposite sides of camera tube. A light barrier telescopes to accommodate focusing. Effective lens spacing is adjustable from 5 to 7 in. Human eye spacing is about 3 in. Effect of convergence is achieved by adjusting mirrors. Tube-sharing images are high and narrow.

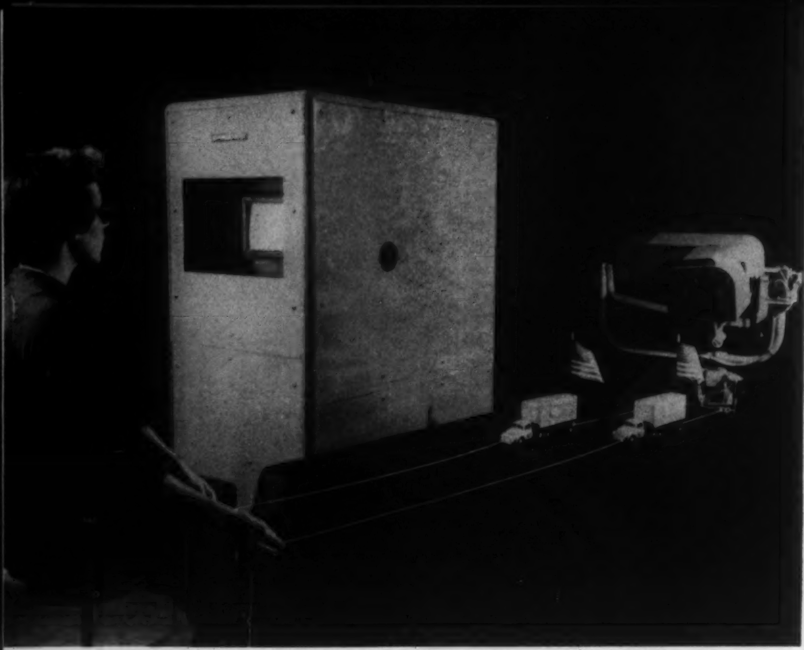
two images interfering or obscuring each other. Proper eye convergence must be stimulated at the same time.

The old stereoscope presented the two images side by side. A glass prism before each eye caused convergence, and a suitable barrier prevented either eye from seeing the other eye's image. A variation of this system was tried at Argonne National Laboratory. One TV camera was fitted with an image splitter which focused two similar pictures on a transmitting tube. The picture tube showed the two images side by side. Glass prisms used in the viewing spectacles caused convergence, but made it hard for the viewer to look away from the TV screen at other objects. This, and the undesirable tall, narrow pictures, led Argonne to abandon the system for the one now in use.

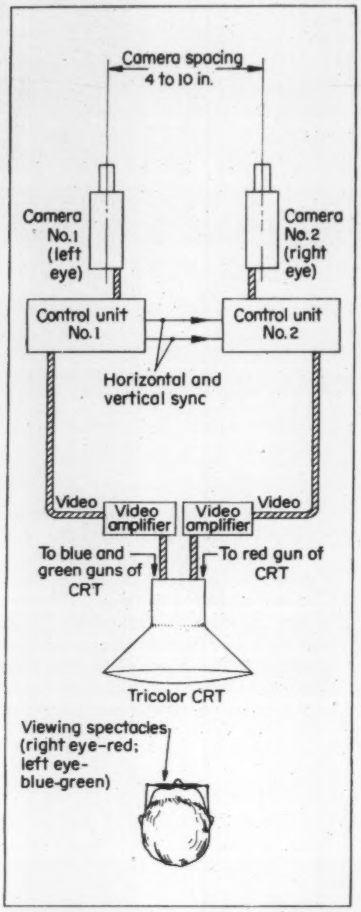
Stereo projection techniques superimpose images to get satisfactory convergence and use two general


Polarized viewing spectacles
Polarized filter
Half-silvered mirror
Observer
Left-eye image in center of this tube
Cathode ray tube
Right-eye image in center of this tube

Images from two picture tubes appear superimposed to the viewer who sees one through the half-silvered mirror by transmission and the other by reflection. Eye lenses are polarized in the same axes as the corresponding picture screens. Argonne National Laboratory is developing this system for use in a new alpha-gamma facility.



Polarized segments of a revolving drum pass the viewing aperture in front of the picture tube in GE's color system. These are synchronized with a selective shutter moving between the two lenses of the camera. Left and right-eye images have equal time, measured in split seconds, on the television screen. The viewer sees 45 images per sec with each eye. Distance between lenses is approximately twice that between human eyes.



One set of interlocks, one viewing tube, and simplicity of design make the Diamond system unusually rugged and foolproof. Adjustable spacing between lenses allows correlation of camera and eye convergence.

methods—eclipse viewing and filtering—to prevent either eye from being confused by the alternate image.

The eclipse method presents first one, and then the other image on the screen in rapid succession. Viewers watch through rotating shutters synchronized with the projected images. Argonne rejected this system because of troublesome flicker and image retention.

A similar alternating presentation arrangement is used in General Electric's color system at the Idaho Falls Nuclear Propulsion Lab. Two camera lenses spaced at twice ocular distance focus their images on a single camera tube. A rotating shutter occludes first one, then the other lens in rapid succession. Synchronized with the camera shutter, a revolving drum passes polarized segments of its surface before the picture-tube face. The result is rapidly alternating left and right-eye images which can be viewed with properly oriented polarized glasses to give the impression of a continuous three-dimensional picture.

Filtering is done by presenting images in two mutually exclusive kinds of light and putting corresponding filters before the eyes. One of the first methods developed uses complementary colors—red and green. One image is projected in each color. Diamond Power Specialty Corp. uses a color TV tube to transmit one red and one blue-green image that can be viewed with red and blue-green glasses for a 3-D effect.

Polarized filters will do the same job and allow the transmission of color pictures. Argonne and GE are working with polarized images in their present systems.

Needed—More Development

Stereo TV has solved some hard problems, but faces some others. The most important is how to get synchronization between pictures. Argonne, with its completely dual TV chain, has found this problem most severe. Linearity has not proved as difficult as was anticipated; the eye apparently will tolerate quite a variation. However, power surges change picture sizes and intensity in a way that is tiring and calls for constant adjustment. Polarized filters and half-silvered mirrors in Argonne's system absorb up to 85 per cent of picture light, calling for a much brighter picture than normal.

One dual-lens camera and a single picture tube solve some of these problems for GE. The biggest problem there would seem to be synchronization between the rotating shutter and the rotating drum on the viewer.

The color tube used by Diamond Corp. is the only method shown yet whereby one tube can present two filterable images without auxiliary equipment. To compensate for the obvious impossibility of transmitting color pictures, they present a system needing a minimum of synchronization; interlocks between

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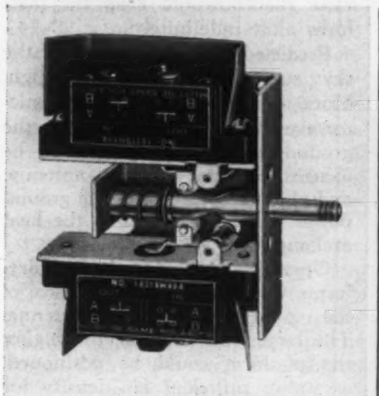

CUTLER-HAMMER SAFETY INTERLOCKS DISCONNECT PANEL POWER WHEN CONTROL CABINET DOORS OPEN

A new control cabinet safety interlock is now available which automatically cuts off the control circuits when the service door is opened. Simple to install, the Cutler-Hammer Cabinet Door Safety Interlock enables maintenance personnel to inspect or repair operating equipment in safety. If desirable, the maintenance man can restore power when the door is in the open position by pulling the operating rod to the test position. The operating rod automatically returns to normal operation when the door is closed.

New Literature

The C-H Cabinet Door Safety Interlock is available with either the single or double contact block operator. New literature on this and other Precision Limit Switch units is now available. Write today for Pub. EA154-L243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

NEW SIZE 4 STARTERS AND CONTACTORS ARE EASIER TO INSTALL, LAST LONGER

To meet the demand for a large horsepower motor starter with "Size 1" life and dependability, Cutler-Hammer developed a new family of NEMA Size 4 across-the-line starters and contactors rated 50 Hp @ 220 volts, 100 Hp @ 440/550 volts maximum polyphase. Much of the improved performance and increased life of the new Cutler-Hammer Size 4 Starters and Contactors stem from the unique double break, parallel-contact design. This design provides multiple points of contact making it virtually impossible for "contact-bounce" to open all current paths simultaneously. Contact arcing is thereby minimized resulting in vastly improved electrical life. Further, the double break, parallel-contact structure permits the use of low mass moveable contact members resulting in reduced impact wear on the contacts and contact linkage. Repeated tests prove this new design provides substantially longer mechanical life over conventional contact structures.

Simplified Installation

A host of plus features make the new panel mounting C-H Size 4 components easiest to install. New line and load lug type terminals use a retractable serrated pressure plate to positively secure the connections without risking wire damage. Flanged lug supports prevent their turning when tightening the terminal lugs. All terminals face forward for easy access. Straight-through wiring and permanently marked terminals minimize wiring errors.

Direct Action Electrical Interlocks

The new C-H Size 4 Starters and Contactors will accommodate a maximum of four extra electrical interlocks. Easiest to install, the externally mounted interlock is held in place by two screws. The moveable contact guides of the interlock and contactor mate to form a rigid link between the two . . . no special adapters needed.

New Literature

Write today for the illustrated publication giving full details of the new C-H Size 4 Starters and Contactors. Pub. EN-125-L243. Cutler-Hammer Inc., Milwaukee 1, Wisc.

PANEL BUILDERS HANDBOOK SIMPLIFIES SELECTION OF ELECTRICAL COMPONENTS

This handy 82 page reference guide is specifically edited to assist design engineers and control panelbuilders in the selection of electrical control components and control accessories. Every effort was made to make this book as concise as possible, and yet it includes such vital information as wiring diagrams, dimension drawings, ratings, ordering information, and a maintained price list. Address your request for your personal copy of Bul. EE120-L243 on your company letterhead. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

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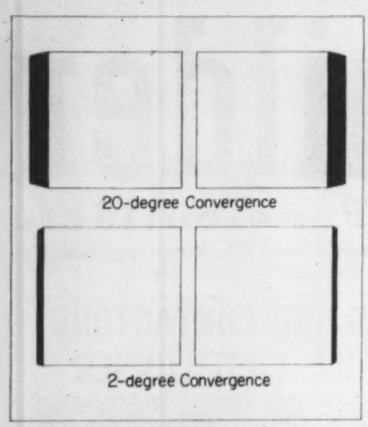


Convergence has a bearing on depth interpretation. Both stereo pairs show a ½-in. cube. The upper pair shows a normal view of the cube from 8½ in. The lower pair shows the cube as it would appear from 40 in. with ocular spacing. If the lower pair is viewed with as much as 10-degree convergence, the mental image will be a wafer rather than a cube.

camera controls do most of the job.

All three systems demand considerable mental adjustment on the part of the viewer. He must compensate for lack of linearity, variation in intensity and size between images, and slight irregularities in masking in the Argonne system. His eyes must alternate rapidly in reception and retention of pictures in the GE system. He must ignore color coding in the Diamond Power system. Even cross-polarization of images must cause some conflict in reception between the two eyes. In all systems he must compensate for distorted perspective of objects not at optimum viewing distance for the setup used.

In its infancy, stereo television shows growing pains. Pictures flicker and jump. Eye strain and mental fatigue are the result of conflicting picture information. When proper requirements are met, the viewer seems to be watching a tiny isolated 3-D scene in a little black box.

Better synchronization, more complete eye information, wider range of vision, wider tolerance on viewing position, less and more comfortable viewing equipment—these are some of the development goals that may put stereo TV in the parlor.—T. M. LEACH

Microwave Beam Furnishes Practical Wireless Power

New Vacuum Tube Licks Excessive Heat Problems; "Fuelless Sky Stations" Feasible, Says Raytheon

WALTHAM, MASS.—Turning on the radio to fuel-up with weightless fuel may not be as far-fetched as it sounds. A new microwave amplifying tube is giving life to an old dream: Wireless transmission of power.

The tube, a superpower Amplitron developed by Raytheon Mfg. Co., handles many kilowatts of power. Until now, standard microwave amplifier tubes have been limited in power-handling ability by heat buildup. Rate of dissipating unwanted heat produced in the conversion of alternating current into microwave energy limited power output. The problem has been solved in the improved Amplitron, says Raytheon.

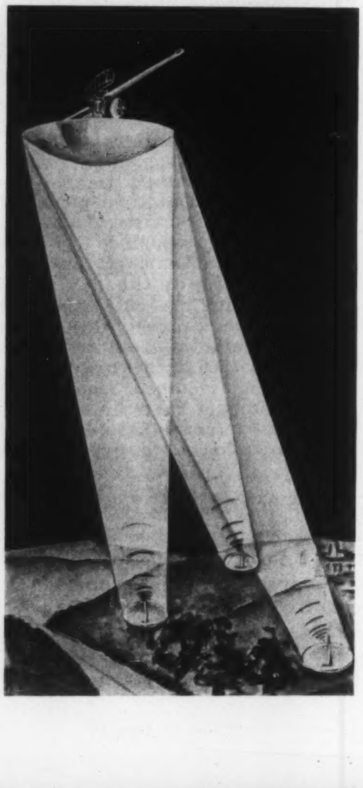
One possible application for the new tube is beaming microwave power to a sky station. While no contract has yet been awarded, the proposal is receiving close attention by the Air Force.

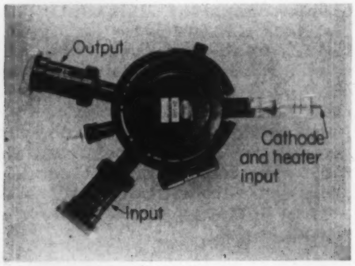
"Weightless fuel" would be generated by a battery of Amplitrons at a ground station and beamed to a hovering helicopter-like sky platform. On the platform, an antenna would pick up the microwaves and conduct them through wave guides to "lossy" elements. These elements would convert the microwaves to heat. Compressed air, heated by the "lossy" elements, would drive a heat engine. Turbine-driven rotor blades would keep the platform aloft indefinitely.

Predicted overall efficiency of the sky station is remarkably high. More than 50 per cent of the microwave power generated at the ground station is expected to be focused on the airborne antenna, and about 35 per cent of the ground power will be delivered to the heat exchangers.

Operating altitude of the platforms would depend on the size of the power-transmission antenna. The larger the antenna, the higher the platform could be positioned, assuming sufficient air density for the rotor blades.

Lightweight supplemental engines will propel the platform from the earth to its assigned position, and will also provide emergency power should the microwave beam be interrupted. These engines will also return the platform to earth for servicing.





Amplitron, a vacuum tube microwave amplifier, may prove to be the key to wireless power transmission. Newer models of the tube can handle power levels 20 to 100 times greater than earlier models. This is due to improved cooling systems that remove ten times more heat than previously possible. The tubes probably will make semistationary sky platforms feasible. Such stations, fueled by radio broadcast, could tie into existing aircraft early warning networks and, for this reason, are being carefully considered by the Air Force. Sky Stations could also find use as communication and television relay stations, and as weather-detection and prediction aids.

Underwater TV Eye Sees in the Dark

SCHENECTADY, N. Y.—Nuclear submarine *Skate* was able to operate and surface almost at will in the Arctic Ocean on its recent winter voyage to the North Pole. A supersensitive television camera tube developed by General Electric Co. was able to spot faint light patches on the underside of the dark ice. These patches indicated "lakes" where newly formed ice was thin. Here the *Skate* could surface.

The new tube is reported by GE as 100 times more light sensitive than other tubes of its type. A special film target only millionths of an inch thick is the key to the tube's sensitivity.

The system was developed for the Navy, and for the Army's Night Vision and Fire Control Program. It is so sensitive that it can literally "see in the dark." It produces bright pictures on a TV receiver of objects in areas too dark for the human eye to see anything. Further, it does not require any special "invisible" light such as infrared.

Addition of the TV system to the *Skate* gives it the best "eyes" available to any submarine in the world, says GE. It, with other U. S. submarines, is already equipped with the best "ears."

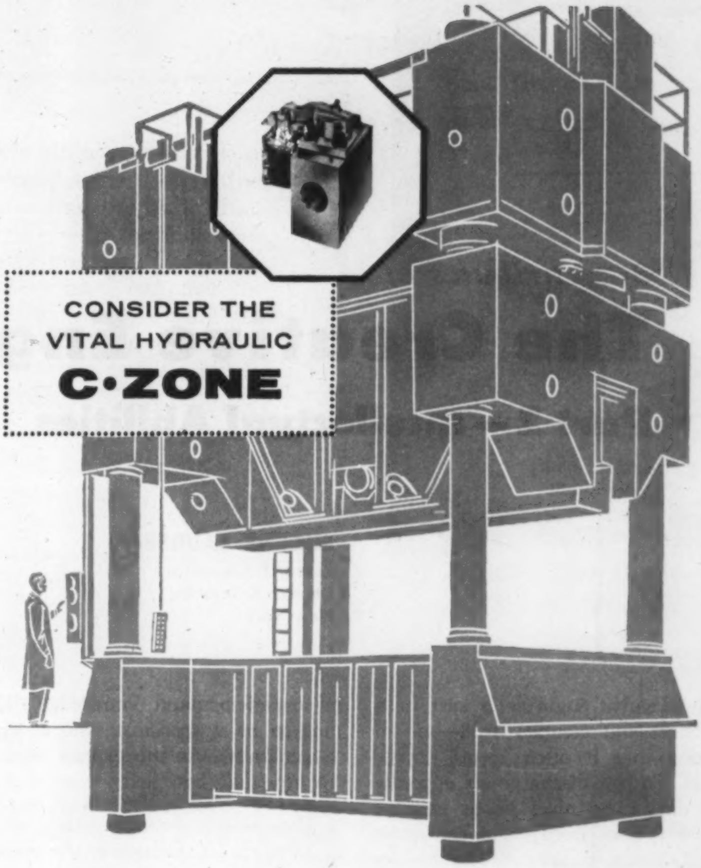
MD Wins Two Awards For Editorial Content

CHICAGO—In the 21st annual Editorial Achievement Competition for Business Publications sponsored by *Industrial Marketing*, two certificates of merit were presented to MACHINE DESIGN. The July 24, 1958 issue, featuring "Electric Motors," was judged an outstanding single issue. "Human Factors Engineering," a six-part series which began in the April 17 issue, was a winner in the outstanding series category.

In making this year's awards, the 28 judges evaluated 555 entries.

Answers to Space Man Quiz

1-*b*, 2-*b*, 3-*d*, 4-*a*, 5-*b*, 6-*c*, 7-*d*, 8-*c*, 9-(D), 10-(C), 11-(E), 12-(B)



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In hydraulic systems . . . both stationary and mobile . . . solenoid valves are often a vital part of the *Control Zone*. When you specify *Waterman* for either AC or DC solenoid valves, you're assured that they won't limit the efficiency of the system. Waterman Solenoid Valves (like the ⅜" Model 474 shown above) are pilot operated, for wider valve opening, lower pressure drop, less power consumption; fast, positive valve action; operating pressures up to 3000 p.s.i. with high-strength aluminum alloy bodies; easier installation; complete accessibility of all working parts; continuous-duty solenoids. Every Waterman valve is factory-tested before shipment. And yet all this extra value costs you no more. Specify Waterman — and be *right . . . from the start.*

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Also suppliers of AN and MS qualified flow regulators and fuses.

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WATERMAN
ENGINEERING COMPANY

Circle 415 on Page 19

30 Attributes of

The Creative Engineer

Part 2 — Intellectual Abilities

EUGENE RAUDSEPP
Research Consultant
Deutsch & Shea Inc.
New York

The creative engineer is cast in a difficult and complex role—one so taxing that it often seems impossible. To best discharge his appointed duties, he must be as creative as he is able. Even so, he can never be "ultimately creative," for he can always increase his creative powers.

The "building blocks" of creativity are, according to a recent survey of experts in the creativity field, thirty basic attributes common, in varying degree, to all creative engineers. Attributes that are personality traits were discussed in the first article of this series, appearing in the May 28 issue of MACHINE DESIGN. In this second article, eleven intellectual abilities of the creative engineer are discussed.

Knowledge of the Fundamentals . . .

The realization is growing that no one can continually progress in any specialized field unless equipped with a mind versed in many fields. Technology has evolved to such a degree of complexity and difficulty that continuous studying in many diverse fields is required to contribute creatively.

The creative engineer certainly has to be a specialist in one field. But he also has to be counterbalanced by a breadth and versatility of experience and knowledge. He has to be a specialist who is also a generalist. As the experts say:

- *The creative person . . . can then search through widely scattered fields following the many paths that lead to the multiple solutions that he knows exist. He can take basic information from various fields and find application in others.*—A. L. SIMBERG, General Motors

- *The creative engineer has a good reasoning power that is based upon a firm foundation of engineering fundamentals. This is more than solving of problems by manipulation or formulae; it is the understanding of the physical significance of the basic laws of science. This is also the ability to see through the superfluous clutter that is found in all engineering problems in order to find the core of the problem.*—C. F. HIX JR., GE

- *As the scope of his creative work depends upon his store of knowledge, he should be constantly engaged in enlarging this store by study, experiment, and observation. He must therefore have a high capacity for self-instruction.*—WM. H. EASTON

- *The engineer should not concentrate his energies to the extreme of becoming too narrowly specialized. A reasonable proportion of his reading, observation, and study devoted to other industries will repay the effort not only in factual information but in creating a broader perspective from which to view his own work. Often some small by-product of an investigation, if noted by an inquiring mind, becomes the catalyst to launch new progress in another direction.*—D. W. MCLENEGAN, GE

As these statements indicate, the creative technical man has an intelligence that is active, intense and acquisitive. He is continually engaged in the study of new, unusual and complex matters. He is constantly expanding his sources and his extent of knowledge. He is often willing to start learning something from scratch if he feels that this is necessary for his work, and he studies mainly during his own free time to extend his technical knowledge.

Creative Memory . . .

The unconscious is a storehouse. The creative engineer's unconscious is always richly stocked. But the acquisition and possession of a pro-

The thirty attributes discussed in this three-part series of articles are of value to everyone concerned with the creative process. The engineer, through understanding the basic characteristics of creativity, can consciously develop those characteristics he does not already sufficiently possess. The interviewer charged with hiring creative personnel can use the thirty as a nucleus for intelligent questions to evaluate the potential of each technical applicant. The manager will find them an aid in understanding creative people and an aid in fostering an atmosphere conducive to creative work.

digious memory is not, in itself, creative. Professor Ralph W. Gerard of the University of Michigan explains it this way:

> • *The general experience has been that the memory wizards are likely to know everything but are not able to do much with it; they are not creative people. There are, of course, notable exceptions; if you happen to be a memory wizard you may also be creative, but the chances are strongly against it.*

Dynamic mobility makes memory creative. Where the noncreative memory files data and impressions in a neat order of independent cubicles, the creative memory has permeability in its structural boundaries. All kinds of unrelated data can always be cross-indexed and interassociated. Further, in the creative mind a continuous rearranging, pruning, discarding, relating and refining of ideas and impressions is going on incessantly day and night. In such a permeably structured memory there is always the possibility for the formation of new configurations and combinations of ideas.

Flexibility . . .

The creative engineer is flexible in his thinking. He is able to choose and investigate a wide variety of approaches to his problem without losing sight of his over-all goal. He effects quick and frequent reorientation of approaches as different problems and projects demand. He is resourceful in finding and adapting the means for creating and can readily jump from one approach to another.

The associations he forms during the creative process are loose and manifold. Dr. Irving A. Taylor of The Pratt Institute puts it this way: "The highly creative individual allows the material to mill about without categorizing . . . he knows how to relate things and he has flexible and plastic perception . . . The noncreative individual suffers from the 'hardening of categories.' "

Professor Gerard in a recent talk pointed out:
"The great danger of the intellect is that one can always subdivide the universe in some way, and 'nature does not come as clean as you can think it.' We can fool ourselves by dividing the universe in particular ways, by the 'Twenty Question' technique. Most of our thinking is in terms of black or white, up or down, and like dichotomies, with little grading; and such categories put a straightjacket on our mind which impedes the arrival of the new."

Knowledge of the Fundamentals . . .

AMIE AIRCRAFT C

"Hello, engineering department?"

Simultaneous Consideration of Several Ideas . . .

MOTOR
TEST BLOCK

"Off button? . . . Off button!— I knew I'd forgotten something!"

Flexibility . .

"I lost my T-square!"

Ability To Think in Images . . .

Tolerance of Ambiguity . . .

"Wow! That's what I call a set of curves!"

Ability To Think in Analogies . .

Electronic Brain
Gluecky

"Where'd we get this new operator?"

Professor John E. Arnold of Stanford University feels that familiarity results in the affliction of "fixedness": "We see a pencil as only a writing instrument, we never see it as a tool for propping open a window, or as fuel for a fire, or as a means of defending ourselves in an attack."

The creative engineer shows great flexibility and mobility. For him nothing is frozen, static, or permanent. He feels, rather, that he can take nothing for granted, and that the volatile, evolving and unconfined reaches of technological advance have not even been tapped as yet.

Fluency . . .

Professor J. P. Guilford of the University of Southern California suggests that four types of fluency exist: Word fluency, associational fluency, expressional fluency, and ideational fluency. Of the four, ideational fluency is found to have the highest correlation with creativity, especially in the fields of science and engineering. Creative individuals tend to show voluminous productivity as far as ideas are concerned.

- *The creative person is more 'fluent' in his thinking than the noncreative person. He has more ideas per unit time than others. Obviously, they are not all good ideas, but when he completes his list of alternatives, the probability is very high that in that list there will be one or more that are novel and that will better solve the problem that he has set for himself. While it is very doubtful that quantity breeds quality, my experience has been that those who have lots of ideas, usually have the best ones.*—PROFESSOR ARNOLD

While fluency is important in the creative engineer's repertoire, it has to be strongly coupled with the ability to identify which ideas are best and the selectivity to attend to the more fundamental aspects of a problem.

Observation . . .

The creative engineer is a keen observer. He is more aware of the unfulfilled needs in products, devices, situations and circumstances than his less creative colleagues, and he feels impelled to find solutions to these needs.

He is watchfully observant when performing experiments or surveying new materials and phenomena. The exceptional, contradictory, paradoxical or unusual happenings that occur are grist for his mill. He seldom takes the obvious for granted and he seeks to place his problems in ever new perspectives in order to arrive at solutions from unique vantage points. He has the capacity to not only note the unusual and the different, but also to see resemblances, similarities and analogies among a multitude of differences.

Originality . . .

The creative engineer displays originality in his thinking in that he can think of unusual, unique solutions to his problems. He is able to take apart firmly structured and established systems and create new ones from many disparate elements. He is able to see remote relationships and to associate ideas and facts into new relationships. As Simberg puts it: "He can penetrate into divergent areas and find remote relationships that the noncreative person cannot see or recognize until they are pointed out to him."

In addition, the creative engineer is always ready to see something unexpected, something novel, something fresh in everything he encounters. He is generous toward unusual ideas, whether they be his own or his associates. In fact, it has been said that the creative person's openmindedness extends to the point of gullibility in accepting bizarre or even crackpot ideas and that he plays around with such thoughts quite seriously before relegating them to the dust-bin as useless or invalid. New perspectives, ideas and venturesome conceptions provide an endless source of exercise for his mind.

Ability To Think in Images . . .

It was an image analogy which started atomic physics. In order to find an explanation for the atomic structure of the elements, Nils Bohr used the image of tiny spheres circling in orbits, and in order to throw some insight into the processes within the atom he made use of the image picture of a miniature planetary system.

Another support for the "image-method" of creating came from Einstein: "These (creative) thoughts did not come in any verbal formulation. I very rarely think in words at all. A thought comes, and I may try to express it in words afterwards."

Other noted creative thinkers have stated that they first try to "feel" what they think or imagine, before "naming" it or making it conceptual. In this way they capture the immediacy of their thoughts and are able to retain all the uniqueness and novelty in the incipient insights. The creative engineer's imagery is vivid; it has a quality of concreteness about it, although he may be dealing in abstractions.

Ability To Think in Analogies . . .

Ability to think in terms of analogies has long been recognized as a sign of genius. Aristotle felt no other ability could better convey an individual's creative stature, for it entails the discernment of bondages that link separate phenomena. This requires imagination of the highest order.

In technical fields, analogical constructs have been indispensable tools for discovery and invention. They form the bridge that unites novel ideas with old conceptual frameworks. They not only highlight and illuminate relevant comparisons between concepts, but also introduce and communicate new insights and ideas. Philosopher Morris R. Cohen had this in mind when he wrote that "analogies must play a large part in opening up new fields in science. In its search for the truth, science must formulate some anticipation of what it expects to find. . . . In trying to visualize the unknown, the imagination must clothe it with attributes analogous to the known."

Although analogies are essential in technical creativity, there are two main pitfalls. The first is the overall false impression of completeness created about the phenomenon covered: Analogies frequently take the place of carefully thought out explanations in conceptual terms. The second shortcoming of analogy is lack of precision and exactness: Analogies convey meanings by suggestion and implication, and not by definition. The technical man is well advised to unearth as many analogies as he can when approaching a problem. He should rigorously examine each, and eliminate those that show only a superficial identity in particulars.

Tolerance of Ambiguity . . .

One important reason for lack of creative ideas among many engineers is their strong preference for order and integration. Many react with conservative defensiveness and immediately reject ideas that either do not fit into a secure pre-established pattern, or are too intangible or elusive to permit immediate comprehension.

The creative engineer, on the other hand, is able to tolerate a high degree of ambiguity. He is suspicious of pat explanations. He is always ready to relax binding habit-patterns, and adheres as little as possible to preconceived plans or stereotyped solutions. He shows his lack of rigidity by being able to perceive a great variety of things. He simultaneously considers and balances different or even conflicting and contradictory concepts and elements, without prematurely dismissing those that conflict with his preferences or organizing them into a pattern. The creative engineer has learned to tolerate uncertainty while ordering his thoughts. He has developed a healthy respect for groping and unknowingness during the creative process.

Simultaneous Consideration of Several Ideas . . .

The creative engineer has the ability to hold several ideas in mind at the same time. And these ideas are frequently not even related or have at best only the most tenuous and remote connections. Often they come from conflicting theories or frames of reference, but this does

Fluency . . .

THINK
THINK
THINK

"Boss, I've been thinking . . ."

Observation . . .

"I found your chewing gum."

Originality . . .

"The amazing part of it is, he DOES get five-figure accuracy!"

Intellectual Integrity . . .

"Let's design a machine that does absolutely nothing."

not bother the creative person. Dr. William Shockley of Bell Telephone Laboratories feels that this particular attribute determines creativity in a very important way. As explained by Lindsey R. Harmon of the National Research Council, Shockley's theory of this attribute reads as follows:

- *Shockley's first model is based on the concept that a patentable invention requires a new combination of features and an appreciation of how this combination may be useful. He illustrates this with the self-starter, which in his terms would require a new combination of four distinct ideas brought into awareness at one time. He then postulates an ability of the human mind which would allow the individual to be aware of "X" number of ideas and their relationships. People vary in this ability, so that they can simultaneously entertain 2, 3, 4, . . n ideas. It would thus take a 4-idea man to invent the self-starter in the form Shockley conceives of it. But a 5-idea, 6-idea, or 7-idea man could invent it much more easily, because he could hold the necessary four ideas along with one, two, or three irrelevant ideas. His capacities would allow him, in fact, to consider the four necessary ideas in five, fifteen, or thirty times as many different ways as could the 4-idea man. An increase in brain-power of 50 per cent can thus produce an increase in invention rate of 1500 per cent. Shockley follows out the details of this system to some extent, and shows that this kind of advantage increases very rapidly with increasing complexity of the problem. For example, for a 10-idea invention, an 11-idea man has an 11-fold advantage over the 10-idea man, so that a 10 per cent increment in mental capacity produces an 1100 per cent increase in output.*

Intellectual Integrity . . .

Many authorities have written that intellectual integrity is the first quality of the technical mind. In describing this attribute it would be hard to improve on the classical description Michael Faraday gave of the creative thinker:

- *He should be a man willing to listen to every suggestion but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. . . . Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature.*

The third and final article in this series, in the June 25 issue of MACHINE DESIGN, will deal with the mechanics of creativity.

Metals Matters

Copper and zirconium . . .
are constituents of a resistance-welding alloy that couples exceptionally high electrical and thermal conductivity with strength and hardness. At high temperatures it resists undesirable annealing, but has enough ductility to avoid checking or cracking when stressed at high temperatures. Developer, P. R. Mallory & Co. Inc., Indianapolis, Ind., says it welds aluminum, magnesium, and steel with low melting-point coatings.

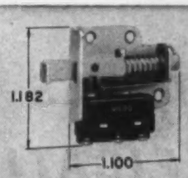
Beryllium only . . .
will be processed at a new plant complying with Labor Department safety recommendations for handling this potentially toxic material. First products from the plant will be electromechanical components for missile and space research. Equipment used is capable of tolerances as close as 0.000025 in. Alsca Beryllium Machining Corp. says its Valley Stream, N. Y. plant is the first east-coast beryllium plant to incorporate Labor Department suggestions. Each machine is hooded and an exhaust system removes beryllium chips, dust, and vapor. Workers wear disposable clothing, eat at an in-plant dining room, and are under daily surveillance by a resident medical director. The entire plant is air-conditioned.

Wire-mesh heating elements . . .
produce temperatures up to 1800 F on honeycomb panels to braze cores to cover sheets without furnace heating. Rated at 5 kva, heaters cover an area 12 by 52 in. Brazes are made in 3 hr using less than 8 w per sq in. Electrofilm Corp., North Hollywood, Calif., reports it has overcome the problem of expansion and contraction of the conductors that plagues designers in the high-temperature blanket field.

Pure niobium . . .
is now extruded in rods and tubes for use in rocket and missile components, and for atomic powerplant parts. High temperature strength and nuclear stability make it desirable for these uses. But until now small amounts of impurities blocked exploration of its characteristics. Wolverine Tube Division of Calumet & Hecla, Inc., Allen Park, Mich., produces rods $\frac{1}{4}$ to 1 in. diam, and tubes $\frac{1}{2}$ to 1 in. OD.

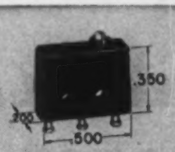
Infrared heat treatment . . .
of superalloys for guided missiles is now done with gas-fired luminous walls that can heat material anywhere from 300 to 2600 F. A. F. Holden, president of A. F. Holden Co., Detroit, says the process is now an everyday technique. Its versatility makes it useful for a wide range of temperatures.

HONEYWELL MICRO SWITCH Precision Switches



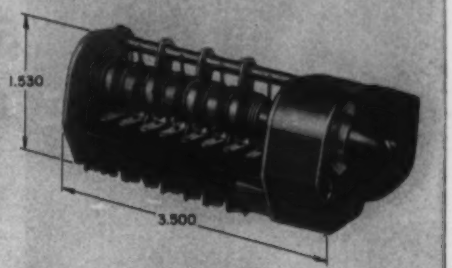
Subminiature door interlock for hazardous equipment

17AC1-T subminiature door interlock switch is the smallest, most compact switch available for an automatic door interlock for hazardous equipment cabinets. Actuator may be pulled to maintained-contact position. It automatically resets when the cabinet door is closed. Dependable in temperatures from –65° to +250°F. Data Sheet 159.



Here is the smallest precise snap-action switch available

Miniaturized subminiature, the "1SX1", weighs but 1 gram, yet is capable of millions of precise operations. Operates dependably from –65° to +250°F. Rating is 5a 115/230 vac resistive, 15a max. inrush. 28 vdc: 7a resistive, 4a inductive; 4a motor load, 24a max. inrush. Data Sheet 148.

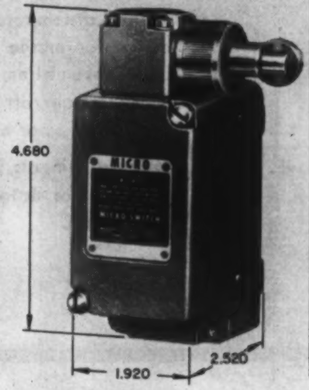


8-circuit selector switch mounts in less than 1.75" dia.

"28AS" Series selector switches have 2 to 4 positions, can control up to 8 circuits. Enclosed SPDT contacts, positive non-tease detents, sealed actuating mechanism. For electronic, computer and aircraft instrument panels. Data Sheet 162.

New "Plug-in Limit" switch with side roller actuator

203LS1 "Plug-in Limit" switch increases the usefulness of the pace-setting "Plug-in Limit" line. These switches, which can be replaced in 20 seconds, are now available in 8 different actuator types. All are rugged, reliable, compact and completely sealed. Their use virtually eliminates downtime. Catalog 84.



A toggle switch that mounts in ¼ sq. in.

1.105
.500
.500

2TM1-T weighs 4½ grams. Ideal for use with printed and transistorized circuits and in compact communication equipment. Operates dependably from –65° to +200°F. DPDT. Data Sheet 158.

5 NEW compact precision switches meet wide variety of industrial design needs

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MICRO SWITCH Precision Switches

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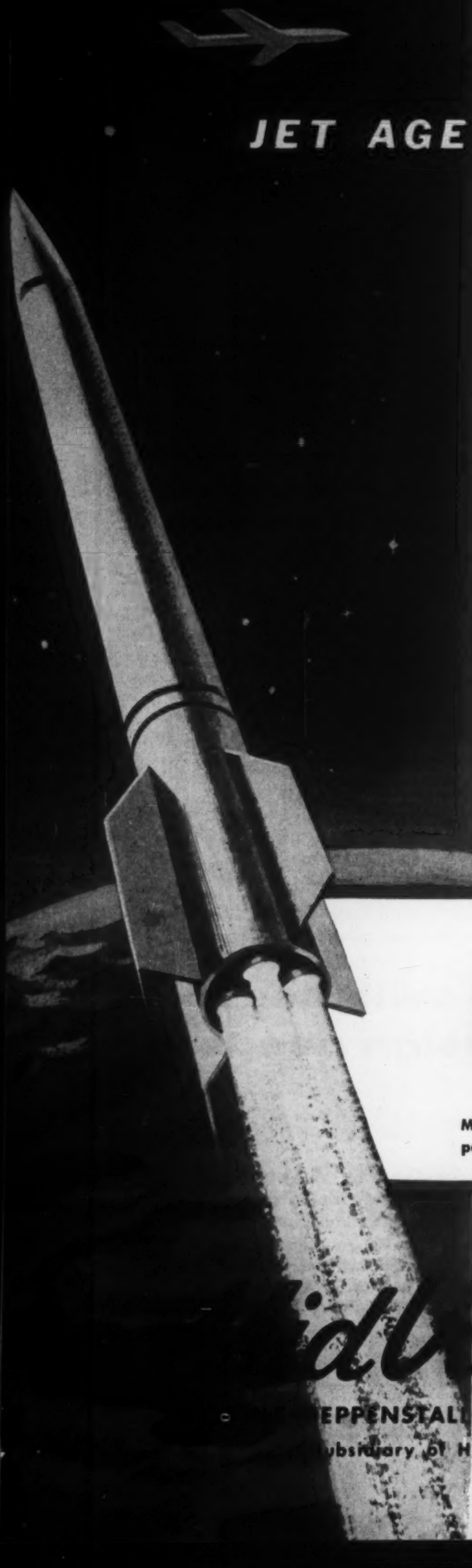

SUPER ALLOY STEELS FOR JET AGE PRODUCT SPECIFICATIONS

by MIDVAC

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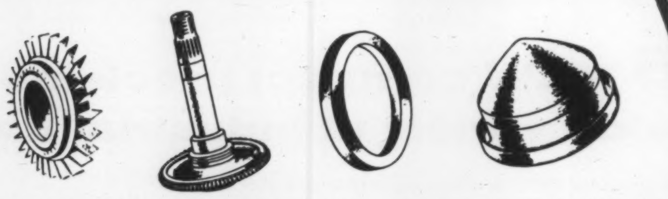
MID-VAC Steels—produced by the MIDVAC Process of consumable electrode vacuum melting—have increased tensile and impact . . . improved stress rupture strength at elevated temperatures . . . long fatigue life. They meet specifications of critical parts where strength is needed at temperatures above 1000°F. Super alloys for missile combustion chambers, tail cone assemblies, nose cone or structural members, aircraft landing gear parts and compressor rotor blades.

Offered in ingots, billets or forgings. Write for technical data on these new super alloy steels.



Midvac Super Alloys for missile combustion chambers, tail cone assemblies, jet engine parts and other parts requiring properties beyond the capabilities of conventional steels.

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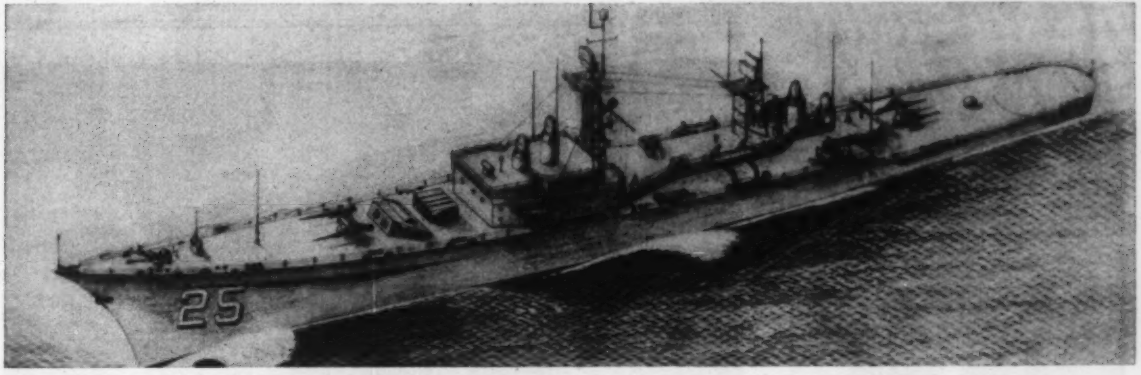


Nuclear Frigate To Carry Guided Missiles

America's first nuclear-powered guided-missile frigate, U.S.S. Bainbridge, is now under construction at Bethlehem Steel's Quincy, Mass., shipyards. Delivery to the Navy is scheduled for January, 1962. Twin surface-to-air Terrier missile mounts will be located fore and aft on the 550-ft ship. She will also carry antisubmarine weapons and conventional armament. Bainbridge joins a fast-growing nuclear Navy. Six nuclear-powered submarines are already commissioned, with 24 more under construction. The nuclear guided-missile cruiser Long Beach will be launched this year, and the nuclear attack carrier Enterprise will be launched next year.

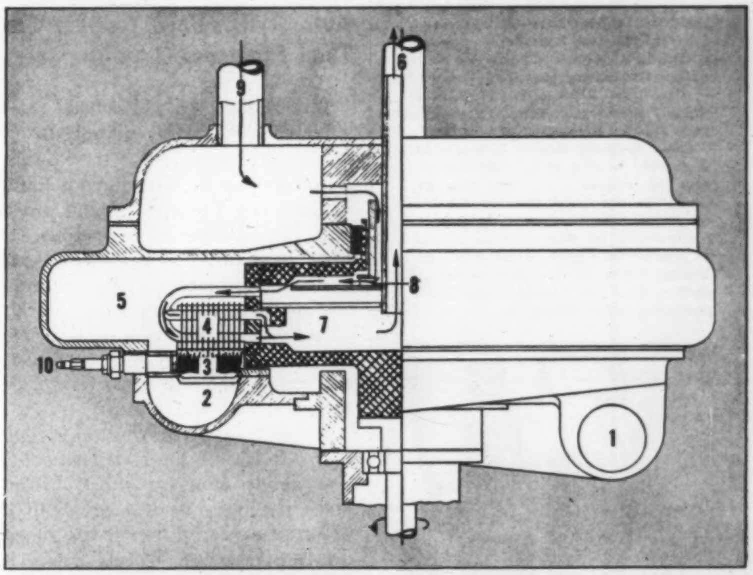
Rotating Tubes Offer New Approach To High-Efficiency Steam Generation

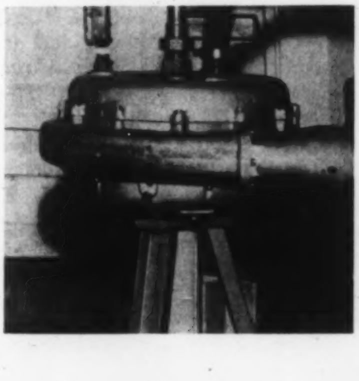
Compact Generator Does Work of Large Boiler

New York—Rotating heat-exchanger tubes, with fins that double as impeller blades for combustion gases, circulate internal fluids by centrifugal force in a highly efficient new steam generator. Premixed fuel and air are drawn through the combustion chamber by the fan-like action of the rotor. Cool water is forced to outer bends of tubes by centrifugal force where it displaces heated water with lower unit mass. Turbulent flow both inside and outside of tubes stimulates high rate of heat exchange.

Pressure at outer tube loops, generated by centrifugal force, inhibits vapor disengagement at rotating tube walls. This, and constant scrubbing of fast-flowing fluids, keep tube walls free of scale. Steam pressure can be regulated by throttling outlet. Hydrostatic head holds steam. Excess pressure is relieved through vent at top of water column.

The Turb-O-Heat generator, manufactured by Turb-O-Heat Inc., occupies 8 cu ft of space and produces 300,000 Btu per hr. It can also be used as a gas or oil-fired liquid heater, or as a liquid heat exchanger. In some applications the rotor may act as a turbine, so the flow of one fluid pumps the other.





Compact generator weighs 150 lb and occupies 8 cu ft of space. It produces 300,000 Btu per hr, equalling production of a conventional unit six times its size.

1. Fuel inlet
2. Fuel manifold
3. Annular combustion chamber
4. Turbo-exchanger
5. Spiral exhaust chamber
6. Steam outlet
7. Steam chamber
8. Rotating coupling
9. Water inlet
10. Igniter

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IN TUBING TOO!

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PRECISION TUBE COMPANY

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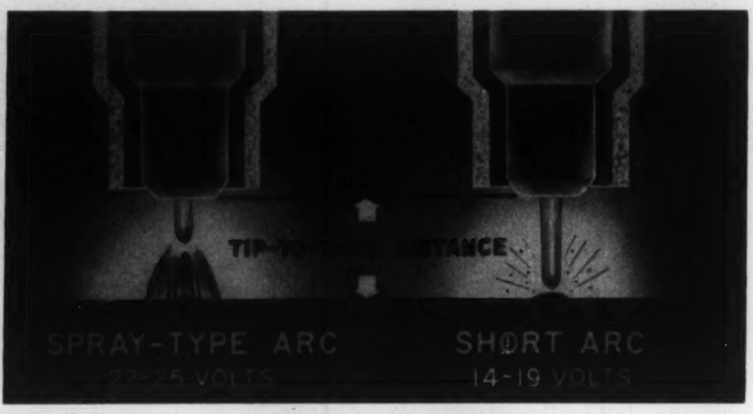


Short-Arc Process Welds Thin Sheet

Controlled power surges occurring dozens of times a second cause a series of short arcs that pinpoint the area of metal fusion more precisely than the traditional welding arc in this new shielded-arc welding technique. Closer work means less splatter and less heating of the surrounding area. Manual fusion welds can be made on sheets of some metals as thin as 0.030 in. Linde Co., Division of Union Carbide Corp., New York, has developed manual and mechanical feeding apparatus for welding wires as small as 0.020 in. diam.

Auto Stylists Have Tougher Job Than Engineers, Says Engineer

Buick's Kelley Also Predicts New Role for Market Analysts

Detroit—People who have a hand in designing Detroit's annual product are almost as numerous as parts in a car, but stylists and engineers are presently the winning combination, according to Buick's chief engineer, Oliver K. Kelley. He rates market analysts as good second-string material, ready to replace the varsity at any minute.

In reaching his conclusion, Kelley says, "It wasn't the stylist who led the parade with his efforts to replace the horse and buggy with a vision of a beautiful air-conditioned drawing room on wheels. And it certainly wasn't the market analyst who took a poll among the horse lovers and concluded what had to be done to arrive at today's picture of automotive transportation. The engineer had to be there first."

Kelley conceded, however, that stylists have a more difficult job than engineers.

"The basic success in engineering comes from evolution, building on top of what you already know, while the stylist seldom has a chance to make evolutionary appearance improvements in his next year's model.

"When the engineer wants the new styling job almost as much as the stylist does, he can find less expensive and better ways to rearrange the mechanism to suit the styling. And when the stylist wants to save the functional values and save the company's money almost as much as the engineer does, he will be happy to take a hard look at possibly beautiful shapes that can be created with less radical mechanical redesigns.

"The stylist and the engineer together form a success team more than any other two people in the business."

The market analyst, according to Kelley, has not been a strong factor in the design of the modern automobile so far, but his influence is being felt.

"We need to know the potential market for each new creation we can construct," he said. "Without this knowledge it is difficult to arrive at the standard volume and the amount of tooling cost per car we should plan.

"Once the utility-cost relationship has been established, together with its indicated market penetration, it will not be difficult to bring into reality whatever the American people will buy in tomorrow's market."

Experimental Rocket Chambers Use Laminated Sheet Metal

Steel Foil Sets New Record For Strength in Cylinders

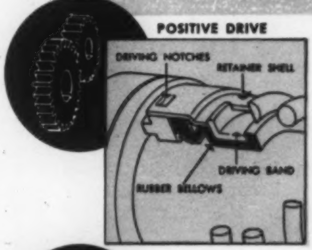
San Diego, Calif.—Layers of steel 0.008 in. thick are wrapped around a mandrel to build up the wall of a unique rocket cylinder developed by Ryan Aeronautical Co. Ultimate tensile strengths higher than 300,000 psi have been achieved by the method. Welding techniques had to be modified to deal with the thin material.

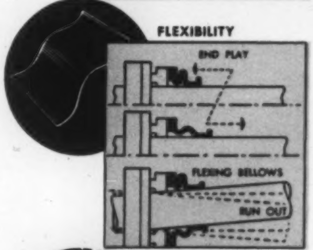
Greater thrust of new rockets has led steel producers to seek new alloys with increased tensile strength. Ryan spokesmen point out that as the strength of a metal is raised, it becomes more brittle, and components made with it fracture more easily. The Ryan program is aimed at this program as well as the consistent attainment of the 300,000-psi tensile strength.

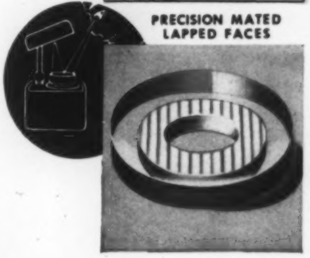
Retarded Computer Becomes Teacher

Complicated enough to stimulate the student while still easy enough to follow in principle, Bell Telephone Lab's SPUD is a new type of teacher. Used for training students in the workings of digital computers and electronic telephone switching systems, SPUD (Stored Program Universal Demonstrator) is neither as fast acting nor as complex as a commercial computer. Changing a punched card is all that is required to have SPUD do a new task.

JOHN CRANE Shaft Seal Design With A Purpose!


POSITIVE DRIVE
DRIVING NOTCHES
RETAINER SHELL
DRIVING BAND
RUBBER BELLOWS


FLEXIBILITY
END PLAY
FLEXING BELLOWS
RUN OUT


PRECISION MATED LAPPED FACES

POSITIVE DRIVE

This gives long seal life. Drive is transmitted through the driving band and washer driving notch which absorb all breakout and running torque. Damaging stresses on the bellows or flexible sealing member are eliminated. Slippage is also eliminated, thus protecting shaft or sleeve against galling.

FLEXIBILITY

Axial and radial misalignment problems are eliminated. Self-adjusting bellows or sealing head automatically compensates for shaft end play or run out. Minimum spring pressure is required for axial shaft movement and uniform spring pressure is maintained during radial shaft movement.

PRECISION MANUFACTURE

Leakproof performance is assured. Washer and seat surfaces are precision lapped to a perfect mate under a patented "John Crane" process.

A SEAL FOR EVERY SERVICE

All "John Crane" Seals are constructed to the particular service requirements . . . from hot or cold water to the most destructive acids, corrosives and gases . . . temperatures up to 1000°F. . . . pressures to 1200 psi. They can be furnished in types and sizes to meet practically any mechanical or dimensional condition.

Request Bulletin S-204-2. Containing full information on "John Crane" engineered shaft seals.

GET COMPLETE DETAILS

JOHN CRANE
Mechanical Seals
CRANE PACKING COMPANY

Crane Packing Co.,
6425 Oakton Street,
Morton Grove, Ill.
(Chicago Suburb)

*In Canada:
Crane Packing Co.,
Ltd., Hamilton, Ont.*

John Crane
MECHANICAL PACKINGS
SHAFT SEALS
TEFLON PRODUCTS
LAPPING MACHINES
THREAD COMPOUNDS

CRANE PACKING COMPANY

Get better protection...more reliable

...WITH GENERAL ELECTRIC

operation for your product

TRI 55 CLAD ENCLOSED MOTORS

REG. U.S. PAT. OFF.

HERE'S WHY:

External Features: Moisture-resistant sealing compound is applied on carefully machined rabbets to assure better protection against moisture and dust. Corrosion-resistant, non-sparking fan on all enclosed fan-cooled Tri/Clad '55' motors resists action of the strongest acids and alkalis. Jet action cools motor effectively and efficiently for long-life operation.

Lead connections are protected from contact with moisture and dirt by a cork-neoprene gasket between halves of the easy-access conduit box.

Further, a new lead positioner gasket between conduit box and frame is impervious to cutting fluids—protects internal parts effectively.

Internal Features: Mylar* polyester film insulation and Formex† magnet wire provide greater moisture and heat-aging protection. Water-resistant stator coating also guards against failure due to moisture. And G.E.'s advanced bearing system gives years more service.

General Electric offers you the most complete line of enclosed motors in the industry, including standard enclosed, severe-duty (for highly corrosive atmospheres), and explosion-proof motors.

CONTACT your nearest G-E Apparatus Sales Office now for *personal proof* on why G-E Tri/Clad '55' enclosed motors can do a better job for your applications. And ask for a free copy of these descriptive motor bulletins: 1-5 hp—GEA-6240, GEA-5980, and GEA-6341; 7½-125 hp—GEA-6602. Or write for them to Section 840-20, General Electric Co., Schenectady 5, New York.

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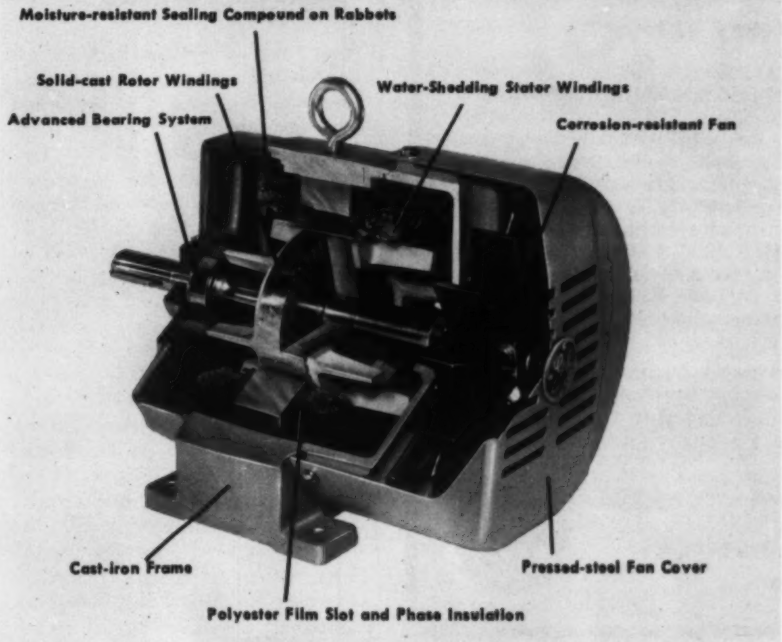
*Registered Trade-mark of DuPont Co.

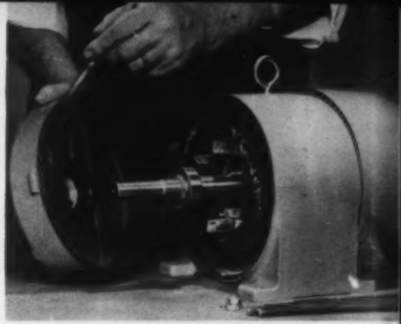
†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC

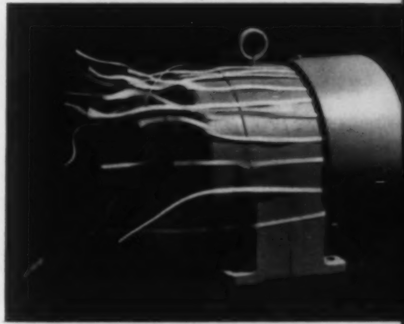
COMPARE THESE TRI 55 CLAD FEATURES


Moisture-resistant Sealing Compound on Rabbets
Solid-cast Rotor Windings
Water-Shedding Stator Windings
Advanced Bearing System
Corrosion-resistant Fan
Cast-iron Frame
Pressed-steel Fan Cover
Polyester Film Slot and Phase Insulation

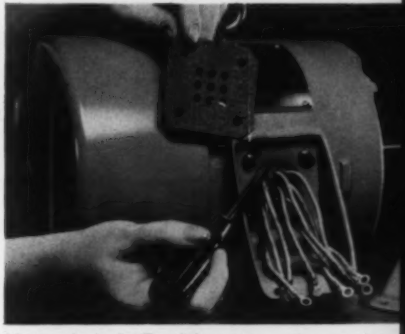
Standard enclosed Tri/Clad '55' motor



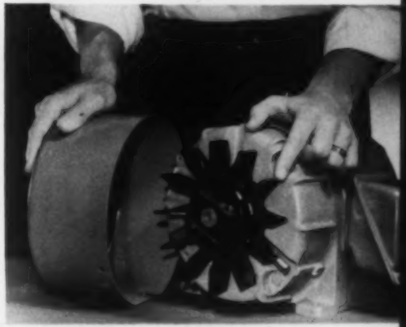
Water-resistant Rabbets protect against moisture, dirt, and abrasive dust for longer life.



Efficient Jet Cooling System spreads a smooth blanket of air over the entire motor frame.

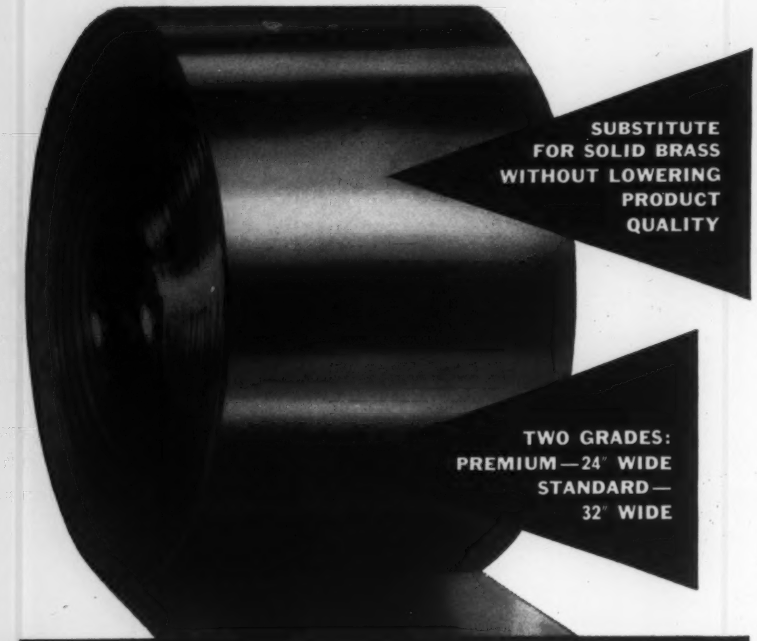


New Lead Positioner and gasket saves connection time; is impervious to cutting liquids.



Non-sparking Fan effectively cools the motor—resists action of strongest acids and alkalis.

NEW PRE-FINISHED
BRASS-STEEL
SAVES 25% OR MORE
ON MATERIAL COSTS


SUBSTITUTE FOR SOLID BRASS WITHOUT LOWERING PRODUCT QUALITY
TWO GRADES: PREMIUM—24" WIDE STANDARD—32" WIDE

Combines the Decorative Properties of Brass With the Economy of Steel

Where the only BRASS you *need* is the brass you *see*, save 25 percent or more on material costs, reduce production steps with brass-plated steel. This way, the only BRASS you pay for is the substantial brass coating you *really need*. Big 32" wide coils — the widest ever made — in Standard grade, for utility or decorative uses; 24" wide in Premium grade, our finest quality — an economical substitute for pure brass for many applications. Both grades are sealed with BAKEKOTE, a baked resin film. Mar-Not protective coating protects the pre-finished surface during fabrication. Big 24" and 32" wide coils and sheets — bright and satin finishes and crimps. Also stripes in sheets, only.

UNPOLISHED — For those parts designed beyond the fabrication limits of our regular pre-finished material, consider *unpolished* Brass-Steel. Excellent for post-finishing work or for applications where high surface finish is not required.

Write For More Information

NICKELOID METALS
SINCE 1898

AMERICAN NICKELOID COMPANY
PERU 8, ILLINOIS
Mills: Peru, Ill. and Walnutport, Pa. — Sales Offices Throughout the U.S.A.

Hose Built Without Splicing

Large-diameter hose (2 to 8-in. ID) is built in a continuous cycle that eliminates splices through a new Goodyear Tire & Rubber Co. process. First production of unspliced hose is a 4-in., 500-ft version for transporting military fuels. Commercial uses will be in offshore loading of tankers, offshore drilling, industrial waste disposal, and temporary pipelines. Continuous hose-building process, a closely guarded secret, resembles tire building.

Teflon-Aluminum Sandwich Makes Mold-Release Film

Metal Strength Offered
With Cling-Free Surface

New York—Plastic products formed by heating under hydraulic pressure will not stick together when separated by films of a new laminated material called AMFoil. Du-Pont Teflon is bonded to one or both sides of aluminum foil at 900 F to form the new product. Foil thickness ranges from 0.0002 to 0.012 in. Thickness of Teflon coat is 0.00006 to 0.001 in. Aluminum keeps film from spreading under pressure; Teflon gives the cling-free surface.

Very thin sheets of the material may be used as insulated flat conductors in electronic applications. Thicker types may be diaphragms or ultrathin gaskets for missiles, jet-engine components, and engine blocks where resistance to wide temperature variation and high tensile strength are important. American Machine & Foundry Co., New York, developed the new material.

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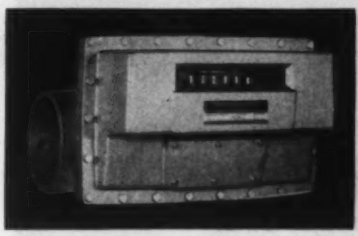
Flowmeter Measures Mass Rather than Volume

New Technique Bypasses Density Calculations

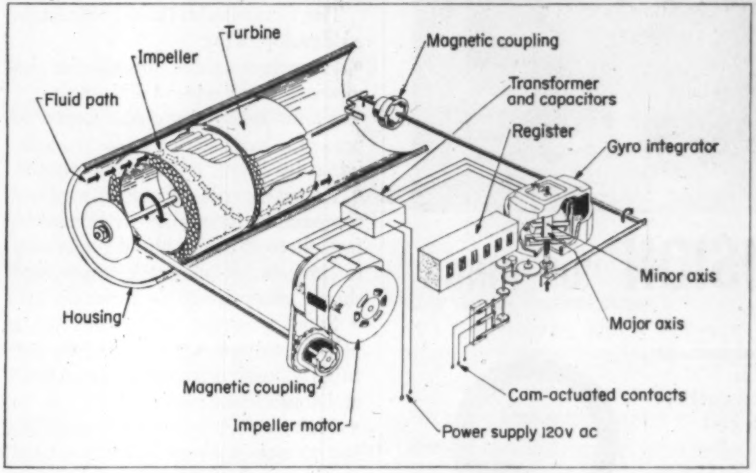
SCHENECTADY, N. Y.—Without interpreting weight from density and volume flow measurements, a new flow meter reads off the flow of fluids directly in pounds. It is applicable to a wide range of fluids—liquid or gas, hot or cold—and can even be used with corrosive acids.

Incoming fluid is given an angular-velocity component by a constant-speed impeller. This component is removed by a fixed turbine which receives a torque proportional to mass rate of flow. The torque, applied through magnetic coupling to the minor axis of a gyroscope in a gyrointegrator, rotates the gyro about its major axis at a rate proportional to the mass rate of flow. A cyclometer register shows the cumulative mass flow in pounds.

Developer, General Electric Co., claims accuracies of 99 per cent.



Schematic diagram shows elements of flowmeter in action. It can be used with a wide range of fluids, since density is not a mathematical consideration. Exterior of flowmeter is uncluttered. Register displays up to six figures.



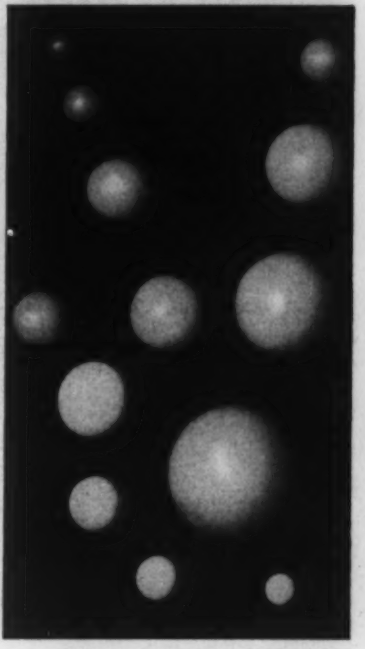
Portable Radiation Counter Needed for Home, Says AEC

Joins OCDM To Call For Detector-Radio Package

WASHINGTON—For adequate safety, every home should have a device to measure radioactive fallout, according to the Atomic Energy Commission and the Office of Civil and Defense Mobilization. They are encouraging development of a combination radiation detector and battery radio to be sold at a price within reach of the average householder. Several companies have models being considered for performance and economy. If approved, the government agencies will strongly recommend them to householders.

The OCDM says that a battery-operated radio in every home will be a defense necessity for a long time. The AEC and OCDM hope a simple radiation detection and measuring device can be incorporated in a small transistorized, battery-powered radio at an additional cost of $5 to $10 per unit. Such a package would serve two survival functions: Receive broadcast information and defense instructions; determine presence and degree of radioactive contamination.

CLEAN AND CLEAR BALLS



OF NYLON AND TEFLON

Because of improved grinding and finishing methods, ITI Nylon and Teflon balls are FREE OF EMBEDDED SURFACE GRIT. Their clean, clear finish assures THE BEST in performance for your products.

These balls are available in all sizes — standard (carried in stock) and special. Samples free on letterhead request.

Write for prices and specifications.

ITI
INDUSTRIAL TECTONICS, Inc.
MANUFACTURERS OF PRECISION BALLS AND BEARINGS
3663 Jackson Road, Ann Arbor, Michigan

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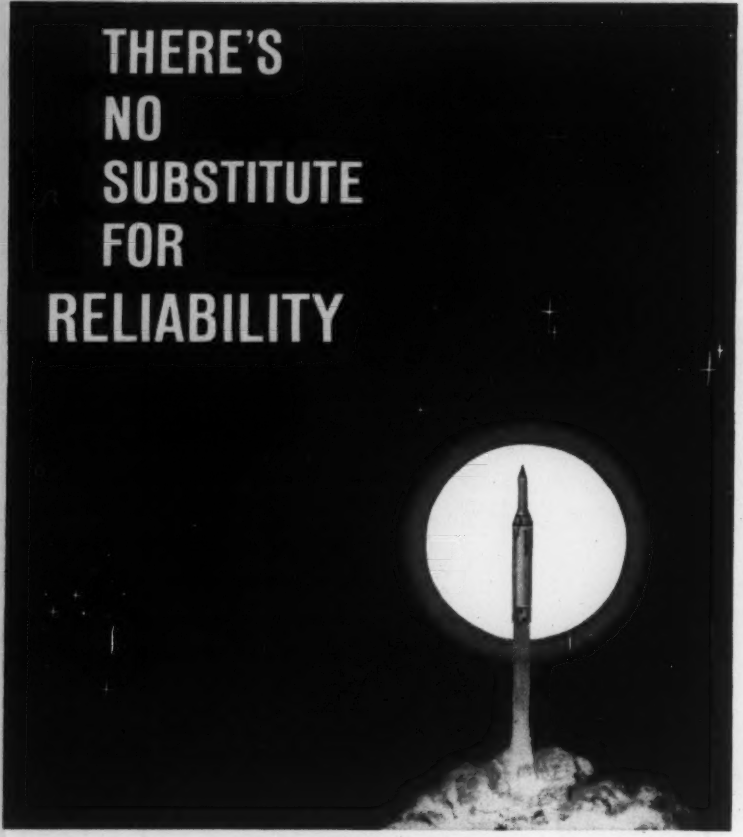


THERE'S NO SUBSTITUTE FOR RELIABILITY

BE SAFE WITH PRECISION "O" RINGS

The more critical the sealing requirments, the more reason to specify Precision "O" Rings. Your investment in Precision quality will reduce assembly costs, rejects and product failures.

Reliability is built into Precision "O" Rings by scientific compounding and a series of over 100 rigid quality control tests and inspections. They're engineered to serve your specific requirement.

For the best in sealing, write, phone or wire for the services of a Precision "O" Ring Specialist today.

*The U. S. Army Missle Juno II requires complete component reliability . . . uses Precision "O" Rings.

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio   Canadian plant at: Ste. Therese de Blainville, Quebec

Circle 423 on Page 19

Inventors Council Lists 28 New Army Needs

WASHINGTON—Problems faced by the armed forces have stimulated addition of 28 new items to a revised list of needed inventions published by the National Inventors Council, U. S. Dept. of Commerce. Ocean cable that mends itself and "Buck Rogers" type flying belts were among the inventions asked for.

Here's how such a self-mending cable might work: Sonic repeaters would be spliced in at lengths along the cable. When damage occurred to a section, it would detach itself from the sonic repeaters on each side. The repeaters would then give an audible signal to guide a self-propelled repair section. The new section would be equipped to couple itself to the repeater on each free end, restoring the circuit.

The Council also listed these needed developments:

- Pressure-sensitive mechanism for measuring altitudes of 500,000 ft.
- Vibration-isolation equipment to protect a basic sensor without modifying its high-fidelity data output.
- Re-usable photographic medium comparable in quality to fine-grain fast photo film. It should be as easy to process as magnetic tape, and should show a visible picture.
- Small pressure sensor not using bellows, diaphragms, or bourdon tubes to read pressures in fluid lines and combustion areas.
- New technique for adding stabilizer to wet sticky soil. Additive must penetrate 2 ft without excessive manipulation.

Meetings
AND EXPOSITIONS

June 16-19—

Institute of the Aeronautical Sciences. National Summer Meeting to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

June 17-20—
National Society of Professional Engineers. Annual Meeting to be held at the Commodore Hotel, New York. Further information is available from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.

June 18-20—
American Society of Mechanical Engineers. Applied Mechanics Div. Conference to be held at Virginia Polytechnic Institute, Blacksburg, Va. Further information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

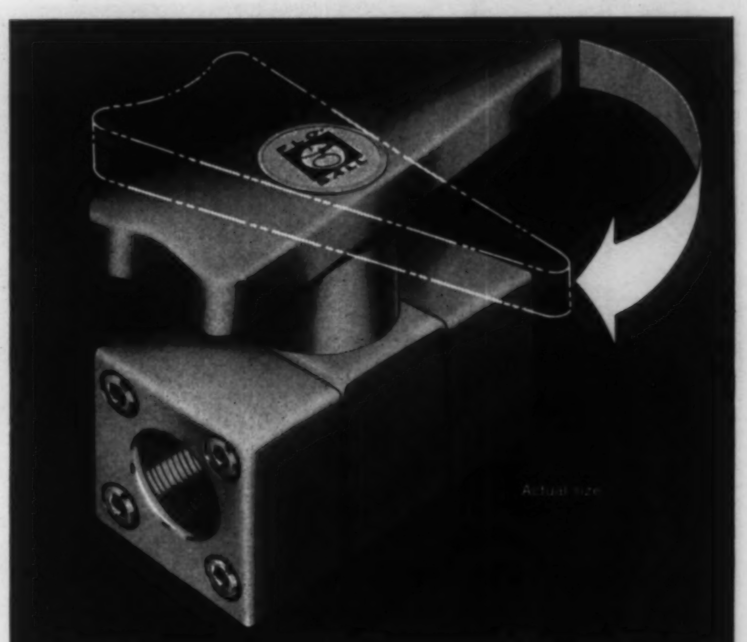
June 21-24—
American Society of Agricultural Engineers. Annual Meeting to be held at Cornell University, Ithaca, N. Y. Additional information can be obtained from Mr. J. L. Butt, Secretary, ASAE, 420 Main St., St. Joseph, Mich.

June 21-26—
American Institute of Electrical Engineers. Summer and Pacific General Meeting to be held at the Olympic Hotel, Seattle, Wash. Air Transportation Conference will be held June 22-26. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

June 21-26—
American Society for Testing Materials. Annual Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

June 22-24—
American Society of Refrigerating Engineers. Annual Meeting to be held at the Lake Placid Club, Lake Placid, N. Y. Additional information is available from society headquarters, 234 Fifth Ave., New York 1, N. Y.

June 29-July 1—
Institute of Radio Engineers. National Convention on Military Electronics to be held at the Sheraton-Park Hotel, Washington, D. C. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.



Replace obsolete needle valves with the

NEW 90° ON-OFF

FLO·BALL

For 3,000 PSI...

Low torque, instant action . . . a fast 90° turn, requiring just 4 inch-pound torque at 3,000 psi, actuates the valve instantly!

Priced no higher than needle valves!

100% flow efficiency . . . straight-thru **FLO·BALL** design has more than twice the flow efficiency of needle valves!

Positive ON-OFF indication . . . large arrow-shaped handle shows valve position at a glance!

Zero leakage . . . Mass Spectrometer tests with Helium prove zero leakage!

Universal mounting . . . can be panel, side, bottom, or line mounted!

Removable flanges . . . damaged flanges can be removed in seconds; no need to replace entire valve!

All stainless steel construction . . . costs no more than old fashioned screw-type valve!

Versatile service . . . ideal for leak-proof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, and many other fluids.

SERIES 715

Port Styles and Sizes

NPT		AND10050	
Size	Part No.	Size	Part No.
⅛	715A1	¼	715A2
¼	715B1	⅜	715B2

Other models are available for service with cryogenic and corrosive media. Also special designs for throttling flow control.

Write today for new catalog describing the world's most complete line of precision valves for industrial and military applications.

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

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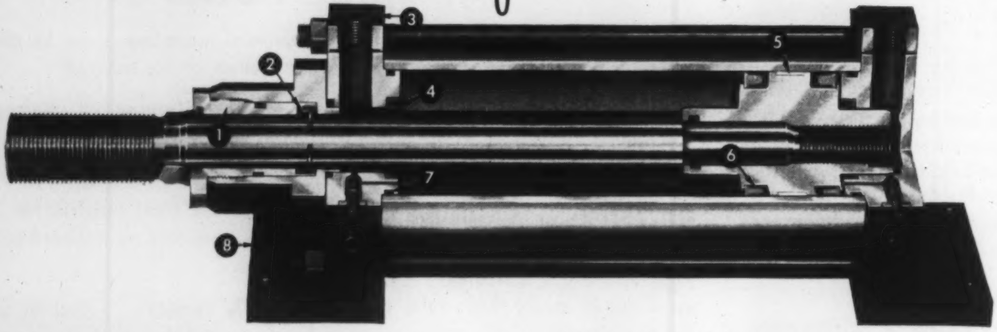
Announcing Valvair®

Valvair
CYLINDER

Check these Valvair features...



① **EXTRA-LONG NOSE GUIDE** provides maximum bearing area for piston rod . . . assures peak resistance to side-loading deflection of rod and piston.

② **CARTRIDGE SEAL** assembly is designed for quick on-the-machine servicing . . . can be replaced without any disassembly of the cylinder.

③ **REMOVABLE PORT ADAPTERS** allow fast exchange of complete cylinder assemblies for bench servicing . . . time consuming piping operations are eliminated.

④ **SELF-ALIGNING CUSHION SEALS** assure uniform cushioning throughout cylinder life . . . unique one-way seal eliminates need for cushion ball check.

⑤ **TEFLON* WEAR STRIP** on piston prevents metal-to-metal contact between piston and bore . . . scuffing or scoring of bore surface cannot occur.

⑥ **NYLON-BACKED PISTON CUPS** for air service, or Teflon-backed O-rings for hydraulic applications, provide positive, bubble-tight sealing throughout the cylinder's operating pressure range . . . keeps break-loose pressures low.

⑦ **POSITIVE BARREL SEAL,** with full-width metal-to-metal contact between barrel and heads maintains leak-free sealing . . . holds dimensional stability under maximum stress.

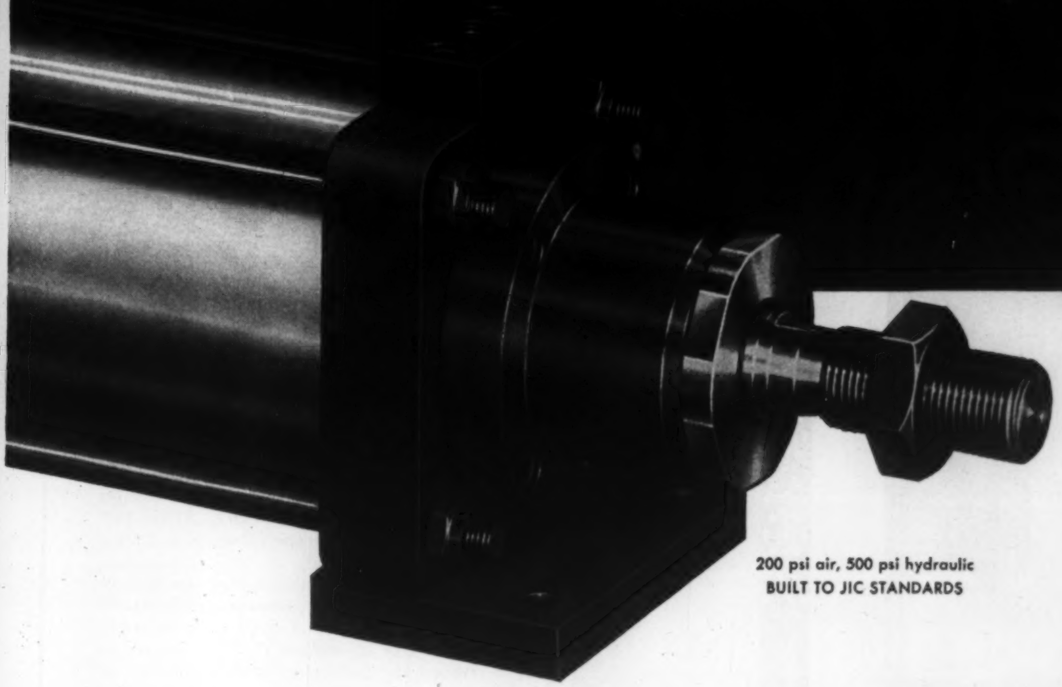
⑧ **RE-USABLE MOUNTS,** with precision-fit load bearing slots, handle heaviest operating loads with ample safety factor . . . are easily changed for modification or re-use of cylinder.

**Trade name for duPont tetrafluoroethylene resin*

8029

VALVAIR AIR & HYDRAULIC CYLINDERS • SPEED KING CONTROL VALVES AND MANIFOLDS • PLUG-IN CONTROL VALVES AND MANIFOLDS

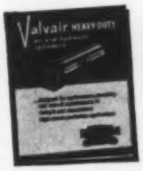
HEAVY-DUTY AIR AND HYDRAULIC CYLINDERS



200 psi air, 500 psi hydraulic
BUILT TO JIC STANDARDS

Here is a cylinder on which you can stake your reputation . . . built by Valvair, makers of famous SPEED KING control valves. With design features based on years of application engineering experience in high-production manufacturing operations, Valvair's new heavy-duty air and hydraulic cylinder offers performance, durability and ease of maintenance. Construction and component materials have been coordinated to assure efficient, trouble-free operation, plus longest service life with minimum machine downtime.

Built to JIC Standards and offering a full range of bore and rod sizes, interchangeable mounting styles, stroke lengths and cushioning options, you'll find Valvair heavy-duty cylinders ideal for your non-rotating cylinder applications. Take advantage of one-source responsibility for all your control system needs . . . cylinders, valves, manifolds, filters, regulators and lubricators . . . call in your nearby Valvair field engineer today.



For detailed information, write for Bulletin VC-800, Address Dept. MD659, Valvair Corporation, Akron 11, Ohio.

Offices in principal cities.

Valvair AKRON 11, OHIO

Other INDUSTRIAL DIVISIONS of IBEC: The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio.

• HI-SPEED INLINE VALVES • PILOT VALVES • MINI-KING VALVES • MANUAL VALVES • FILTERS • REGULATORS • LUBRICATORS

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BISHOP Tubular Products NEWS

"METALS FOR PRECISION AND PERFORMANCE"

BISHOP QUICK SERVICE TEAM SOLVES STICKLER IN ATLAS PROGRAM

Telemetering bulb part (illustrated)—originally of 304 seamless tubing—cracked during fabrication. BISHOP specialists were called in—304L seamless, ½ hard was recommended and supplied (against a tough deadline). *Results:* The 304L part met all requirements, including critical resistance to vibration fatigue within a temperature range of -80° to -380°F in inert helium, and gave completely satisfactory performance in the Atlas program. More information on 304L—or any BISHOP tubular products? Use the coupon.

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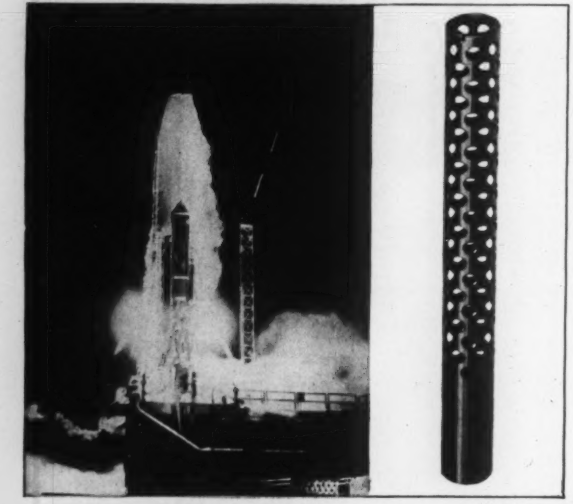
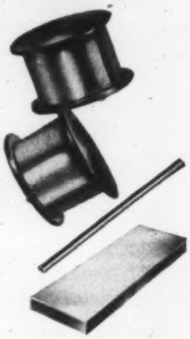


BIMETALLICS NOW AVAILABLE IN MANY DIFFERENT FORMS, METALS



Bimetallics—the new family of composite metal products—is solving problem after problem these days. BISHOP capabilities in producing bimetallics are almost endless. Both *base* and *precious* metals are available in wire, sheet, and tubing form. *Typical example of popular bimetallic for glass sealing applications:* nickel-iron alloys over copper wire in sizes from .004 to .125 in. diameter . . . advantages: *low* electrical resistivity, *good* thermal conductivity. Look into the possibilities of improving *your* products . . . use the coupon.

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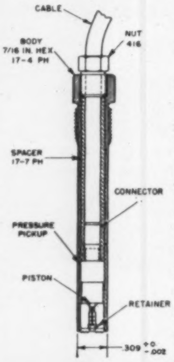


17-7 PH* TUBING BEING DRAWN TO HYPODERMIC SIZE

Small diameter 17-7 PH tubing, welded and seamless, is available from BISHOP now on standard order in sizes down to .375 in. OD X .035 in. wall—on special order to .020 in. OD X .006 in. wall. Accompanying illustration shows a piezoelectric transducer used for measuring pressures up to 100,000 psi in ballistics and hypersonic research work. Use of welded 17-7 PH spacer in transducer permitted finish machining of the part *before* heat treating. Want more data on BISHOP's 17-7 PH products or other super alloys? Use the coupon.

Circle 428 on Page 19

**Trademark of Armco Steel Corporation*

J. BISHOP & CO.

platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ **Bimetallics,** Data Sheet PA-1
- ☐ **17-7 PH alloy,** Data Sheet TA-2A
- ☐ **304L alloy,** Data Sheet TA-2
- ☐ **Tubular Products,** Bulletin No. 12
- ☐ **Platinum Metals Products,** Catalog No. 3

Check information you'd like and mail to
J. BISHOP & CO.,
45 King St., Malvern, Penna.

Name ____________________

Position ____________________

Company ____________________

Address ____________________

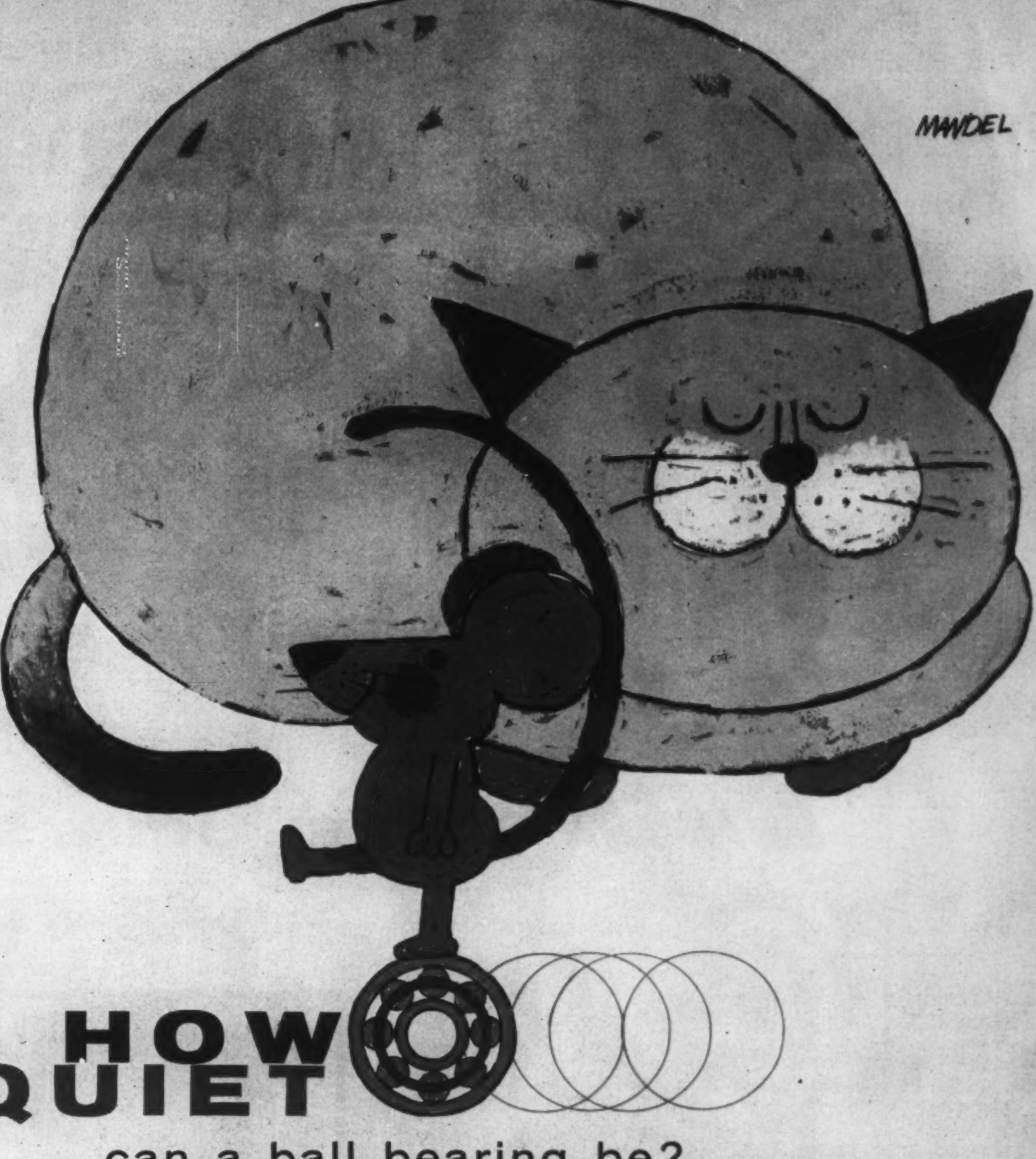
City __________ Zone __________ State __________

Tubular Products Division

45 KING STREET, MALVERN, PENNA.
NIagara 4-3100

THIS IS THE BISHOP LINE:
Products of all the Platinum Metals... Small diameter Stainless Steel, nickel and special alloy tubing

Circle 429 on Page 19→



HOW QUIET can a ball bearing be?

Federal Ball Bearings are to be seen, but not heard! Elusive noises are intercepted by inspection engineers at "quiet control" points all along our production line. They want to hear the soft, sweet purr that signifies a perfect bearing, because that's the only kind we'll tolerate. That's why every bearing goes through scores of quality control tests before we send it out. Customers who get these perfect bearings number among the most respected names in American industry. We'd like to include you. Start with our catalog—over 12,000 ball bearing sizes, hundreds of types. Send for it today.

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Federal
BALL BEARINGS

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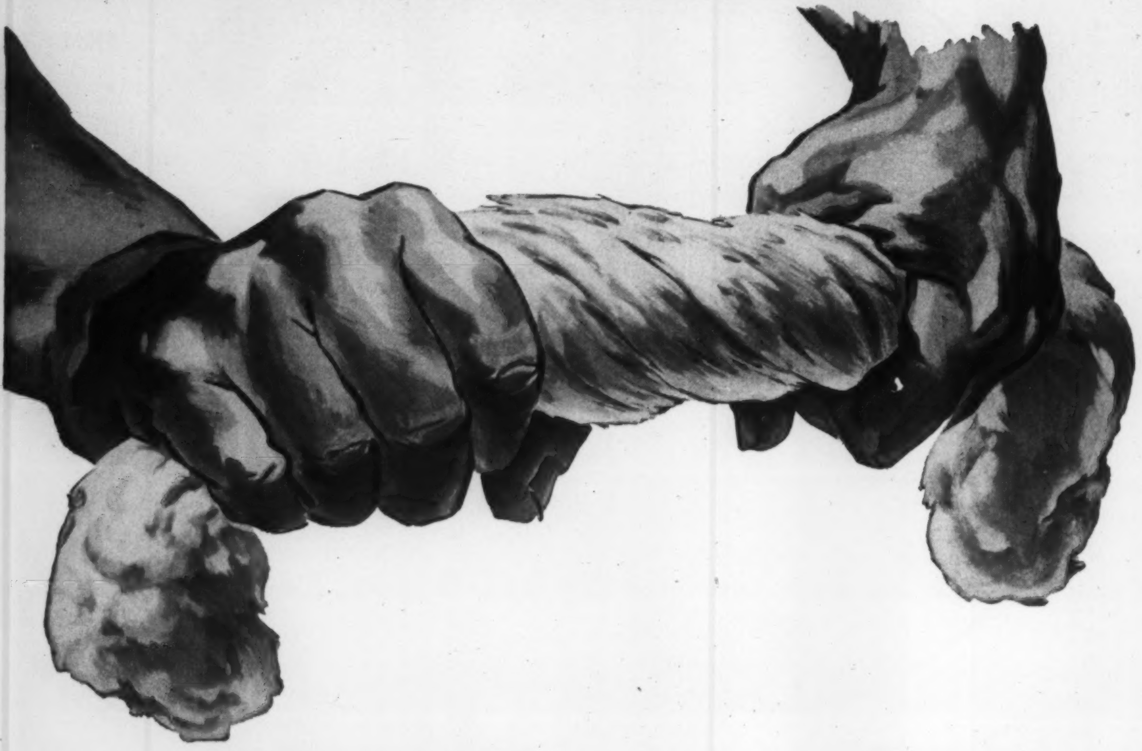
FEDERAL ON FILM—A 16 mm. color sound film takes you through our 400,000 sq. ft. plant. Loaned free. Just ask for it.

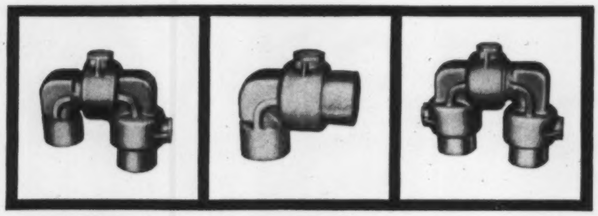
PROBLEM: TORSION FATIGUE ON RUBBER HOSE



SOLUTION: CHIKSAN SWIVEL JOINTS

When twisting and kinking on hose lines present a torsion fatigue problem, look to Chiksan for a ready solution. Chiksan Swivel Joints, with free turning 360° rotation allow hose lines to be flexed without the twist caused by fixed position fittings. With Chiksan Swivel Joints hose lines last longer, maintenance and downtime are virtually eliminated.

Call on Chiksan, depend on Chiksan. Over 1000 different types, styles and sizes have been developed for pressures from 28" vacuum to 15,000 psi and temperatures of –70° to +225°F. A nearby representative is ready to analyze your requirements and make specific recommendations. Write today for his name.



Typical Chiksan Swivel Joints

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A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

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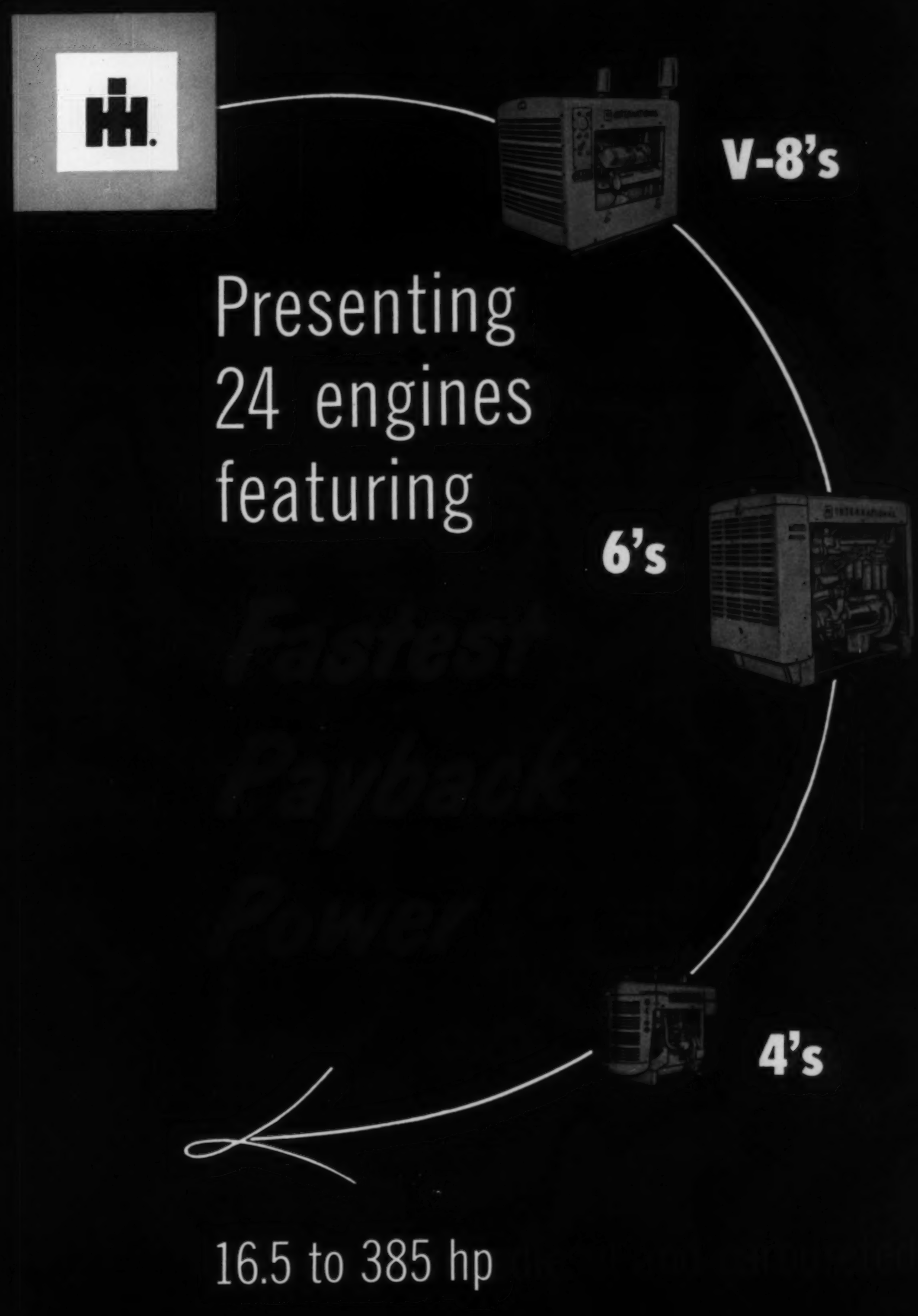
Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Company • Chiksan of Canada, Ltd.

Circle 437 on Page 19

Circle 438 on Page 19→



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24 engines
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Payback
Power

V-8's

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16.5 to 385 hp

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UC-60
16.5 max. eng. hp

UC-135
42 max. eng. hp

UC-221
75 max. eng. hp

UB-220
83 max. eng. hp

U-308
92 max. eng. hp

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95 max

WITH INTERNATIONAL

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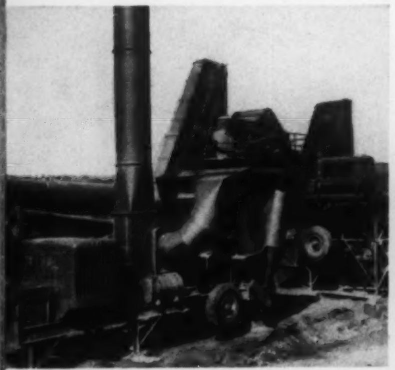
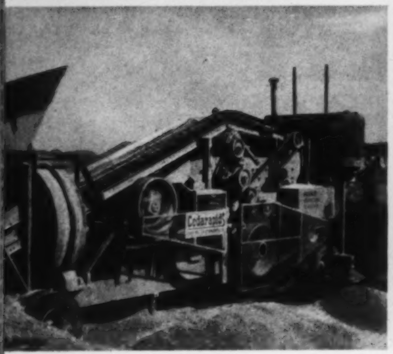
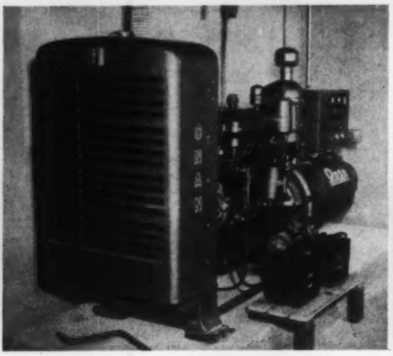




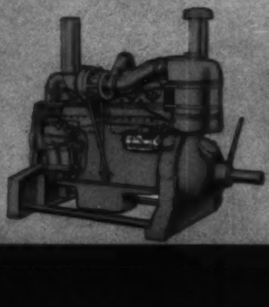


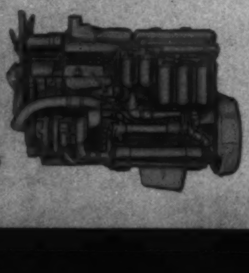
UDT-817
375 int. eng. hp

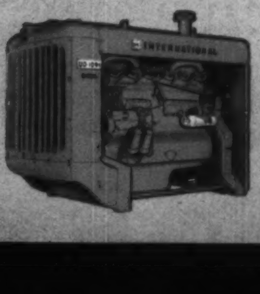
UDT-1091
265 int. eng. hp

UD-817
240 int. eng. hp

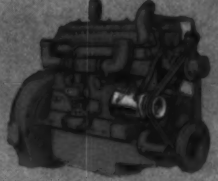
UD-1091
216 int. eng. hp







UC-263
95 max. eng. hp



U-372
110 max. eng. hp

UB-264
112 max. eng. hp

U-450
134.5 max. eng. hp

U-501
141 max. eng. hp

ower starts in your product's engine

Your new products can beat competition by paying for themselves faster on the job. And by specifying International, you can make sure fastest payback power starts in your product's engine.

International engineers with over a half century of heavy-duty engine design experience make fastest payback power the common feature of all International engines through lowest cost operation, long-working stamina, superior sealing, and minimum maintenance.

And it's so easy costwise to match International power exactly to your product without overpowering or underpowering. Choose from 24 models from 16.5 to 385 max. hp. Choose the desired fuel from 10 diesels and 14 natural gas, LPG or gasoline carbureted models in 4's, 6's, and V-8's.

All 24 models are available from stripped engines to complete power units. A wide variety of accessory equipment including air cleaners, flywheels for leading makes of torque converters and clutches, torque converter coolers, air compressors, safety shut-offs, instruments and engine controls can be furnished for your installation requirements. Bases, radiators, hoods and dashes, clutches and power take-offs can be ordered for complete power units.

Your request for more specific information or installation assistance will get immediate attention. Just write or call International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

UV-401—170 max. eng. hp

UV-461—179 max. eng. hp

UV-549—222 max. eng. hp

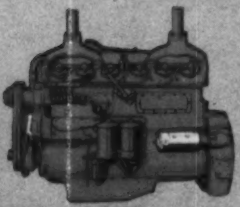
U-1091—248 max. eng. hp
(nat. gas)

CARBURETED

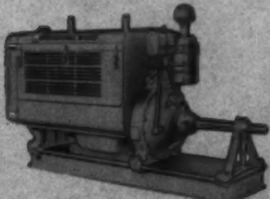
DIESEL

UD-236—70 int. eng. hp

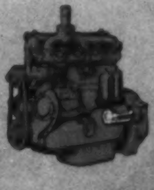
UD-554
140 int. eng. hp



UD-18A
131.5 int. eng. hp



UD-14A
105 int. eng. hp



UD-370
95 int. eng. hp

UD-282
90 int. eng. hp

Your choice of engine sizes and fuels, all with *Fastest Payback Power*

Your International Power Selector

	MODEL	RATED RPM	CU. IN. DISPLACEMENT	GASO. HP	LPG HP	NAT. GAS HP
FOURS	UC-60	2500	60	16.8		
	UC-135	2000	135	42	42	32
SIXES	UC-221	2400	221	75	75	66
	UB-220		220	83	83	70
	U-308	2400	308	92	96	82.5
	UC-263	2400	263	95	95	85
	U-372	2200	372	110	101	92.5
	UB-264		264	112	112	90
	U-450	2200	450	134.5	130.5	112
	U-501	2200	501	141	134	120
V-EIGHTS	UV-401	2800	401	170	165	142
	UV-461	2600	461	179	175	162
	UV-549	2600	549	222	215	192

	MODEL					
FOURS	UD-370	2200	370	262 @ 1400	4⅝ x 5½	95
	UD-14A	1800	460.7	325 @ 900	4¾ x 6½	105
SIXES	UD-236	2400	236	173 @ 1800	3¹¹⁄₁₆ x 3¹¹⁄₁₆	70
	UD-282	2400	282	217 @ 1800	3¹¹⁄₁₆ x 4.39	90
	UD-554	2300	554	400 @ 1300	4⅝ x 5½	140
	UD-18A	1600	691.1	473 @ 850	4¾ x 6½	131.5
	UD-1091	1500	1090.6	825 @ 1150	5¾ x 7	216
	UDT-1091	1500	1090.6	1000 @ 1250	5¾ x 7	265
	UD-817	2100	817	638 @ 1600	5⅜ x 6	240
	UDT-817	2100	817	1052 @ 1200	5⅜ x 6	375

NOTE: *For carbureted engines use 90% of max. hp shown for intermittent type application and 80% of max. hp for continuous type application. For diesel engines use 80% of intermittent hp shown for continuous duty application.*

Specifications subject to change without notice.

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A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom-Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

INTERNATIONAL HARVESTER COMPANY
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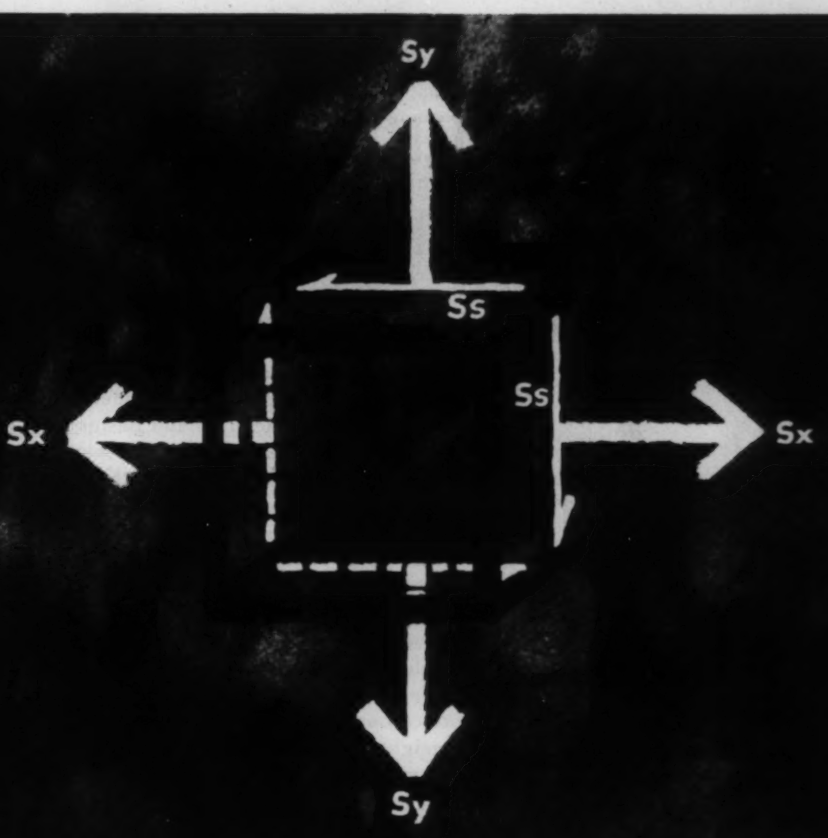


ASSIGNMENT:
ABRASIVE IMPACT

How Lukens *Application Research* helps you find the right steel plate for the job

If your assignment is designing equipment to withstand abrasive impact, our Application Engineering staff can serve you. Their specialty is helping you track down the precise steel plate for any job. They research a problem from the design stage right through to how the equipment has performed for years after its installation. This practical observation and experience—combined with metallurgical know-how—is yours for the asking. It's been saving our customers money for years.

For example: working recently with a conveyor engineer, our people showed why 321 min. BHN quality Lukens "T-1" would perform equally as well as a previously used metal costing twice as much. On the other hand, the same group has suggested the regular quality of Lukens "T-1" for a uranium mine skip hoist, where a slightly softer steel will actually hold up longer. In still another conveyor application—in a coal preparation plant—our engineers demonstrated how stainless steel, Type 304, would produce long-term savings. The high initial cost of stainless was reduced by using it in Lukens clad plate form.

If your assignment is abrasive impact, why not let it be our assignment, too? Contact Manager, Application Engineering, E69 Services Building, Lukens Steel Company, Coatesville, Pa. Also . . . .

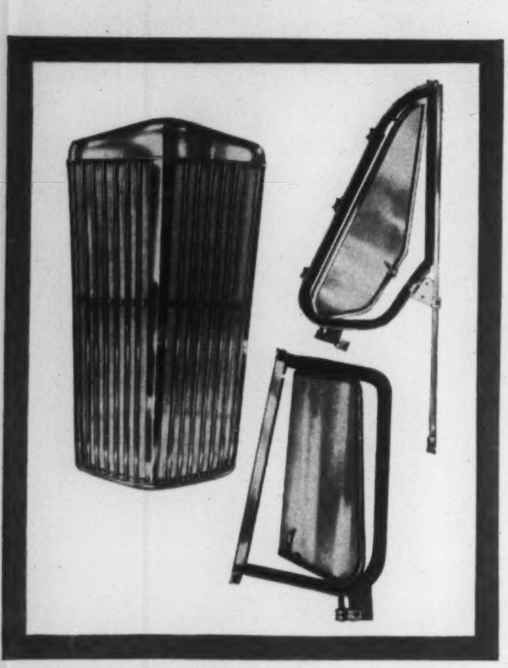
ASK FOR LUKENS "T-1" STEEL BULLETIN

**Helping Industry
Choose Steels
That Fit The Job**

LUKENS

Problem-Solving Products from Republic

FUNCTIONAL STAINLESS STEEL IS CORROSION-RESISTANT, STRONG, WEIGHT-SAVING, READILY FORMED



The high strength-to-weight ratio of stainless steel permits the use of slimmer channels and frames in passenger car and truck sash. Protected by stainless, glass breakage is less likely. Strength, dent-resistance, and corrosion-resistance make stainless ideal for radiator grills. Manufacturer—Excel Corporation, Elkhart, Indiana.

Always right, always bright stainless steel, the optimum metal for trim and brightwork, is showing up in ever-increasing functional applications.

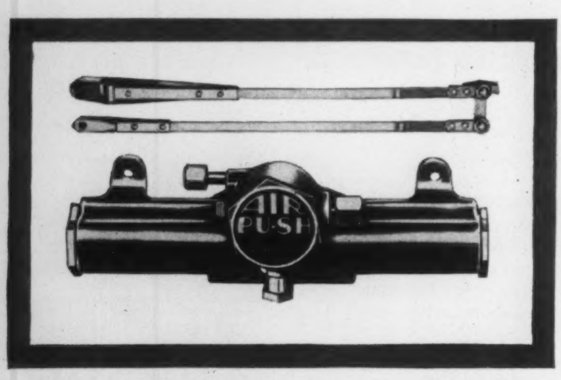
The reason? Stainless steel offers automotive part and equipment manufacturers and designers a combination of qualities unobtainable in any other commercial metal.

Stainless steel parts are tough and strong, yet lightweight. They offer outstanding resistance to heat, wear, and abrasion. They stubbornly resist rust and corrosion. Maintain their great strength through extremes of heat and cold.

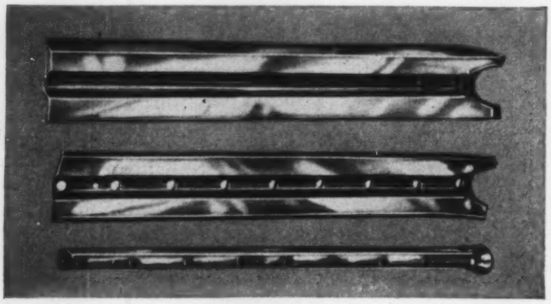
Stainless is readily formed into desired shapes and designs on present equipment with little or no change in procedure and often at lower ultimate cost. Conventional welding techniques, currently in use on production operations, permit the combining of strong, lightweight stainless to carbon steel panels. The result is an over-all reduction in weight without loss of strength or safety, and a structural member that is both functional and decorative.

The functional stainless steel parts and equipment illustrated on these pages represent only a few of many current applications. Others include: mufflers, head gaskets, exhaust manifold butterfly valves, fasteners, heat exchangers. Future applications are practically unlimited.

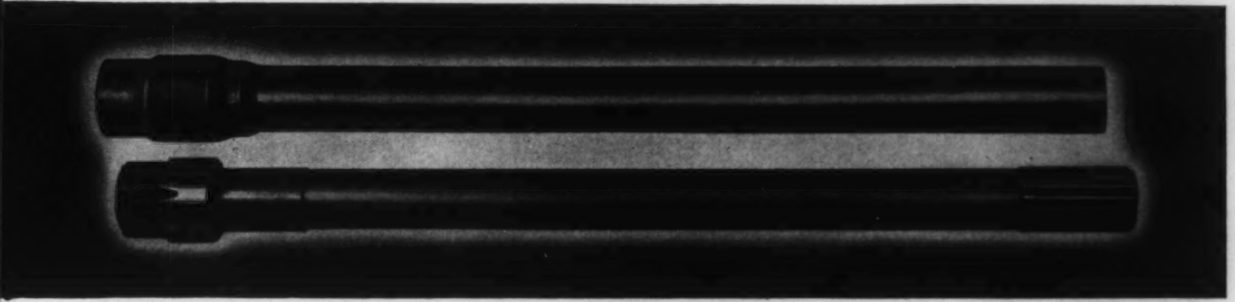
Republic Stainless Steel metallurgists and engineers are always available for consultation on development, selection, application and processing. No obligation for their services. Just mail the coupon.



Stainless steel makes an important contribution to the safe operation and maintenance of windshield wipers. Stainless steel's strength assures resistance to breakage or distortion. Light, strong design reduces dead weight that the wiper motor must move. Elasticity of stainless gives the blade the proper pressure on the glass. The wiper arms are protected against the slow and insidious weakening effects of corrosion. Manufacturer—Sprague Devices, Inc., Michigan City, Indiana.

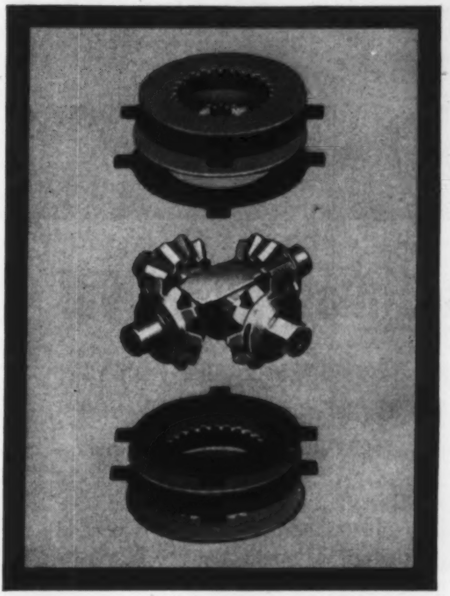


Formability, corrosion-resistance, and cost were prime factors in switching to stainless steel from brass in this engine water distribution tube. Stainless was easily fabricated on existing tools. It took the constant flow of hot water and anti-freeze chemicals in stride. The greater strength of stainless virtually eliminated loss from bent or damaged tubes. Photo sequence shows fabricating operations: (1) Blank of .010″ stainless strip after initial drawing and embossing, (2) Same blank after piercing of water outlet holes trimming of flanges, (3) Completed tube after roll-forming and lock seaming. Produced by Pontiac Motor Division of General Motors Corporation.



NEW FABRICATING PROCESS MEANS ECONOMY. Ford Tractor power take-off countershafts cost less to produce using Republic Die-Form blanks, as compared with previous materials. Blank is shown at top, completed shaft below. Die-Form is a new method of cold forming hot rolled carbon, alloy, or stainless steel bars into multi-diameter blanks ready for final machining. Because Die-Form blanks closely approximate the completed part, scrap losses are negligible. Improved machinability permits savings through use of higher speeds and feeds. Mail coupon for complete facts.

NEW HIGH STRENGTH POWDER, TYPE HS 6460, opens the way for new applications using sinterings for highly stressed parts. Type HS 6460 can be used with existing operating equipment. It provides a minimum tensile strength of 60,000 psi at 6.4 density as sintered, 100,000 psi heat treated. Type HS 6460 maintains its dimensional characteristics after sintering—less than .004 inches per inch shrinkage from die size at 6.4 density. Available in production quantities up to and including 12 tons, or in multiples thereof. Mail coupon for technical data sheet.



SUPER TOUGHNESS AND STRENGTH at critical points are provided by Republic Alloy Steels in the Powr-Lok Differential developed by the Dana Corporation, Toledo, Ohio. Dana engineers have reduced the possibility of mechanical breakdown in clutch rings and side gears to an absolute minimum by forging these parts from Republic Hot Rolled 8615 Alloy Bars. This fine steel offers superior strength and toughness to withstand torque, fatigue, shock, and stress. Uniform response to heat treatment gives the parts hard surfaces around tough cores providing maximum resistance to abrasion, friction, and wear. An exceptionally high strength-to-weight ratio permits the designing of thinner sections to save weight and hold down size. Send coupon for full facts.

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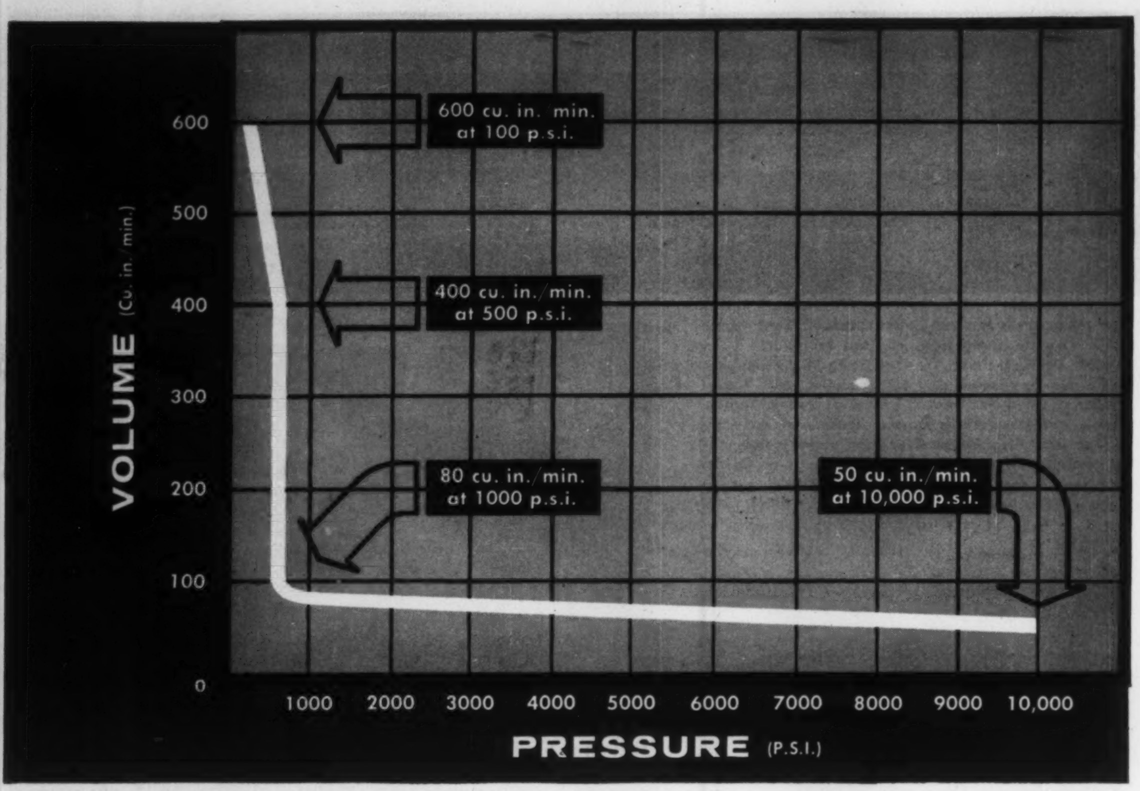
☐ Die-Form ☐ Alloy Steels
Have a metallurgist call
☐ Stainless ☐ Alloy ☐ Metal Powder

Name________ Title________

Company________

Address________

City________ Zone____ State______



New Hydraulic Pump! Look Again at the Curve!

- **LIGHTWEIGHT, TWO-STAGE "POWER PACKAGE"**
- **WT. ONLY 45 LBS., 10¾" x 12⅝", 17½" HIGH**

The amazing, new OTC "Vanguard" hydraulic pumping unit is a quiet-operating, precision-built, two-stage hydraulic pump, driven by a universal motor, and consisting of a gear pump for the low pressure stage and a five-cylinder, axial-piston pump (which is supercharged by the gear pump) for the high pressure stage.

All wearing parts are made of finest tool steel, heat-treated and ground and lapped to assure efficiency and long life.

A variety of valves, controls and accessories are available and are easily mounted to meet your particular requirements.

Here is a power package that might well revolutionize much of tomorrow's designing in high pressure. Your interest, in reading this far, is well founded!

For bulletin and complete information, write:

RESEARCH · ENGINEERING · DEVELOPMENT
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OWATONNA TOOL COMPANY
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Circle 431 on Page 19

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Circle 435 on Page 19

FOR THE MACHINERY PART

THAT TAKES THE BEATING

A cut-off knife made of Haynes Stellite alloy No. 19 slices through molten glass at 2200 deg. F. Despite the intense heat of the glass being molded into tumblers, and the severe erosive action of the glass on metal, the cut-off knife maintains a 0.015-in. clearance between itself and the mold ring . . . *far longer than any other material ever used.*

HAYNES Alloys *will do the job!*

Are you looking for a tough metal part to improve your machinery? It will pay you to look into Haynes alloys. There are more than 15 from which to choose, including Haynes Stellite cobalt-base alloys, Haynes iron-base alloys, Haystellite cast tungsten carbide, and Hastelloy nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. Parts can be furnished machined or ground to specified size and finish.

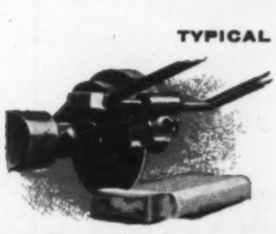
Our engineers will help you pick the right Haynes alloy to resist many conditions of wear, heat, or corrosion.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

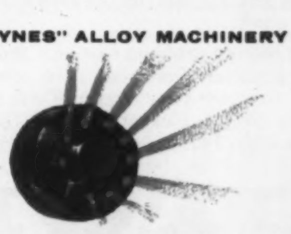
UNION CARBIDE

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

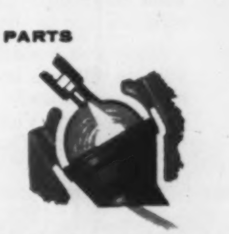
TYPICAL "HAYNES" ALLOY MACHINERY PARTS



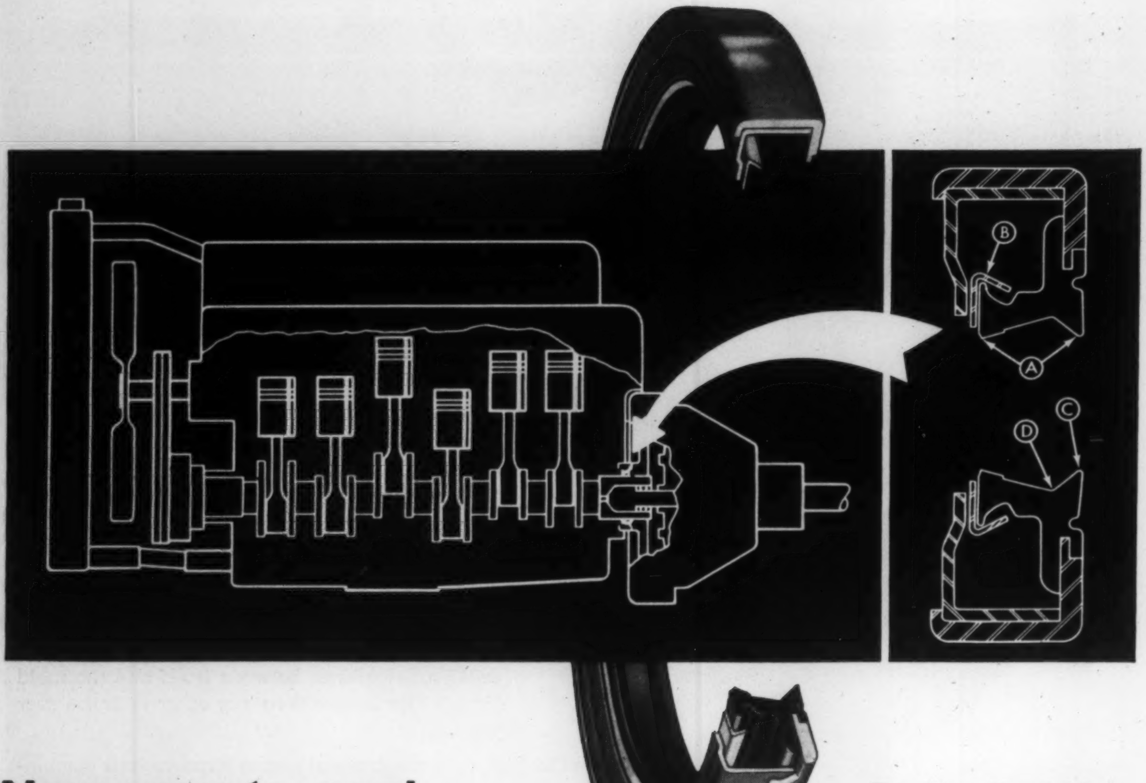
Tough, long-lasting metal-cutting saws over 20 inches in diameter, made of Haynes Stellite alloy sheet, slice the tops off copper ingots.



Steam atomizer fuel burner nozzles of Hastelloy alloy C resist corrosive agents and erosion for months, retaining essential contours.



High-temperature strength and corrosion resistance of diesel combustion chambers made of Hastelloy alloy C make them "good for life of the engines."



New way to seal a diesel crankshaft

Positive Dual-Lip Sealing with Unique Retaining Ring

The tremendous work loads being put on heavy-duty diesels call for a new look at sealing specifications. Stresses on the crankshaft often cause eccentricity with runout as much as .042 in. This makes holding a tight seal at the shaft rear extension with a standard seal design extremely difficult if not impossible. Another consideration is high working temperature—up to 300 deg. F.

Newest provision for this condition on a typical diesel is shown here. This unique yet simple modification of standard Victor oil seal design maintains positive mating of shaft and sealing element under any shaft divergence. The element—a silicone elastomer compounded by Victor—is good to 400 deg. F. intermittently.

In place of the usual garter spring, Victor engineers designed a unique retaining ring, loosely mounted over the sealing lip surface. The ring retains proper lip pressure while it permits the sealing element to follow the exact eccentricities of the shaft.

Have you a shaft sealing problem—or any problem involving oil seals or gaskets? Victor can help you solve it most economically. Contact your Victor Field Engineer or the factory. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

A Basic design is Victor Type K6 with dual-lip standard construction. Provides maximum fluid retention and exclusion of foreign matter. Sealing element is silicone rubber, integrally molded and bonded to steel case.

B Metal retaining ring loosely mounted over the lip replaces usual garter spring. Allows expansion of element when seal is installed on shaft, yet confines element and retains even lip pressure in operation.

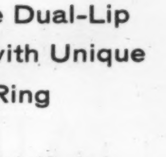
C Outer or secondary lip is molded with very little interference, avoiding danger of turning back lip on installation. When shaft enters primary lip, interference of secondary lip is increased through lever action.

D Lubricant applied between lips before installation permanently lubricates the seal, reduces frictional drag, extends seal life.

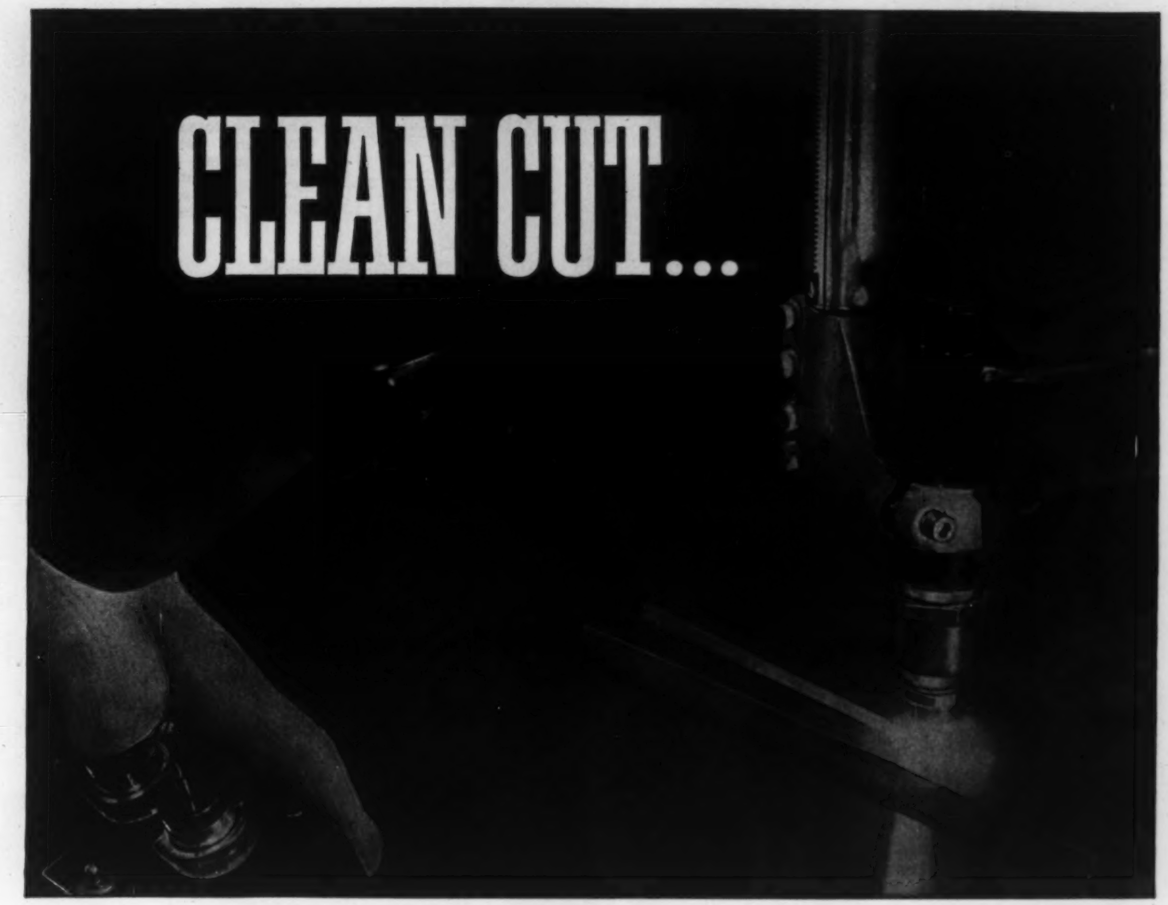
VICTOR

Sealing Products Exclusively

A complete reference manual for designers—Victor Oil Seal Engineering Catalog No. 305. Sent on request.



GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS



... HELIARC Cutting turns hours to minutes

Before: It took 1½ hours to chip an 18-inch hole in an aluminum dome ⅝-inch thick. NOW—The hole is cut in *one minute*—with HELIARC Cutting.

Before: A 54-inch diameter dome hole in ⅝-inch rolled aluminum plate required about 5 hours, with chipping hammers. NOW—Manual HELIARC Cutting does it in about 4½ *minutes.*

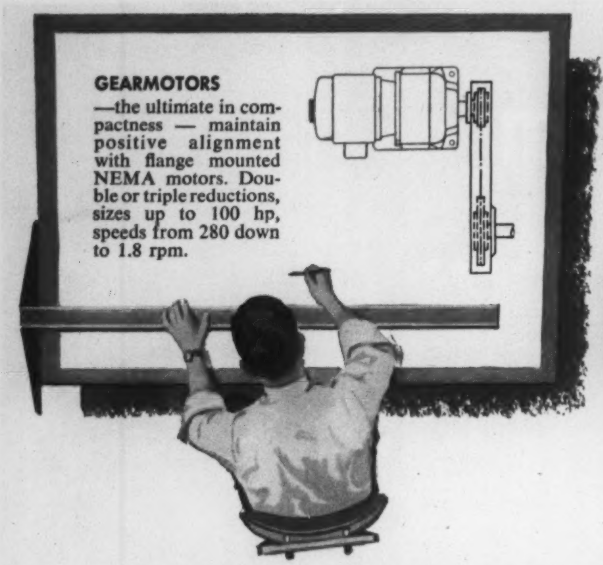
HELIARC Cutting employs an extremely high-temperature, high-velocity arc that gives cutting speeds up to 1000 inches per minute on ¼-inch-thick material. It makes saw-like cuts, either square or beveled, in materials up to 3 inches thick ... *and,* you can take the torch to the work. "HELIARC Cutting is equally effective on aluminum, stainless steel, magnesium, copper and all other metals."

See for yourself—ask your nearest LINDE representative to *prove* that HELIARC Cutting slashes time and labor costs over conventional methods. Call your local LINDE office today! Or write Dept. Q62, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

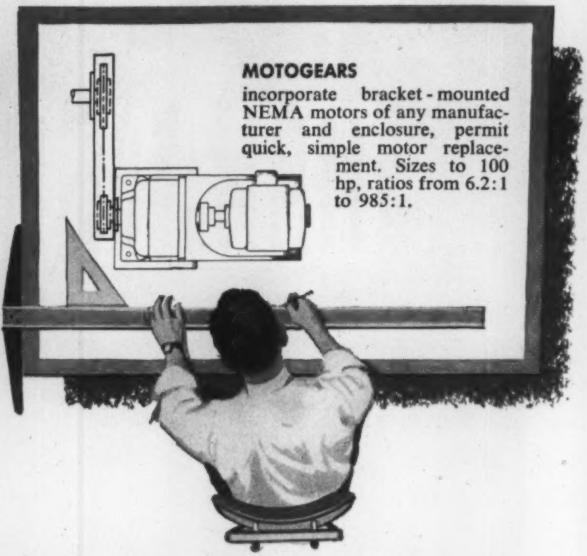
Linde
TRADE-MARK

UNION
CARBIDE

"Linde", "Heliarc", and "Union Carbide" are registered trade-marks of Union Carbide Corporation.



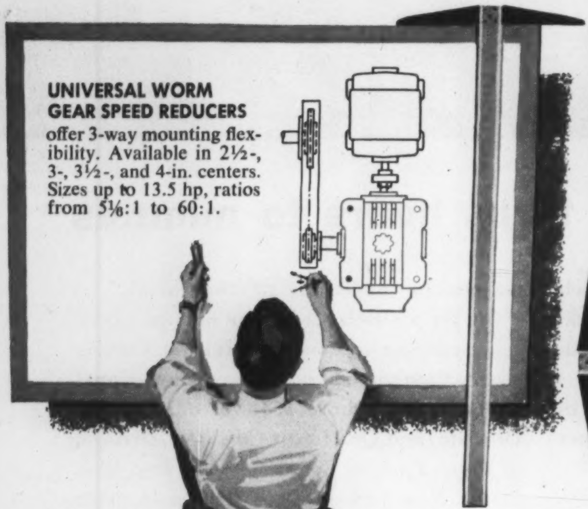
GEARMOTORS
—the ultimate in compactness — maintain positive alignment with flange mounted NEMA motors. Double or triple reductions, sizes up to 100 hp, speeds from 280 down to 1.8 rpm.



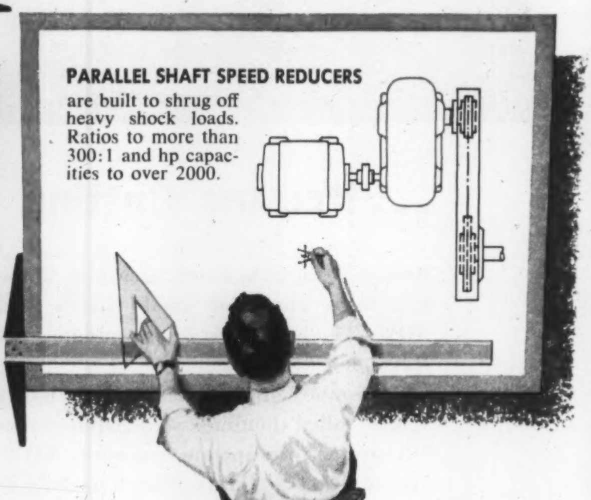
MOTOGEARS
incorporate bracket-mounted NEMA motors of any manufacturer and enclosure, permit quick, simple motor replacement. Sizes to 100 hp, ratios from 6.2:1 to 985:1.

It's industry's only complete line—

don't limit



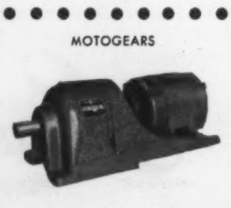
UNIVERSAL WORM GEAR SPEED REDUCERS
offer 3-way mounting flexibility. Available in 2½-, 3-, 3½-, and 4-in. centers. Sizes up to 13.5 hp, ratios from 5⅙:1 to 60:1.



PARALLEL SHAFT SPEED REDUCERS
are built to shrug off heavy shock loads. Ratios to more than 300:1 and hp capacities to over 2000.

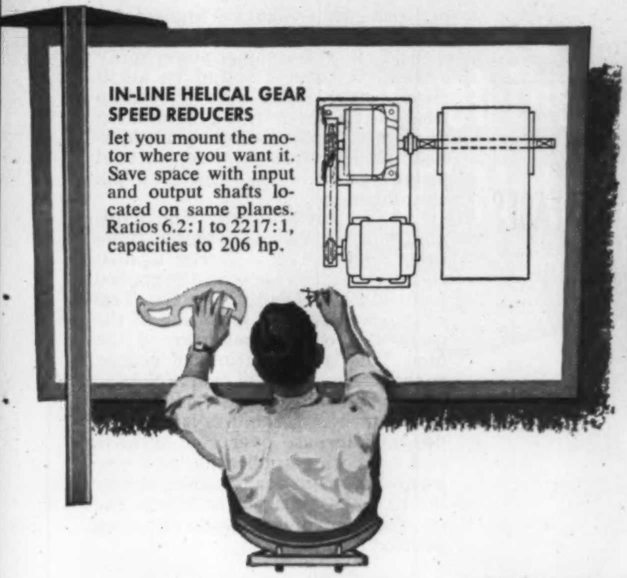
GEARMOTORS

MOTOGEARS

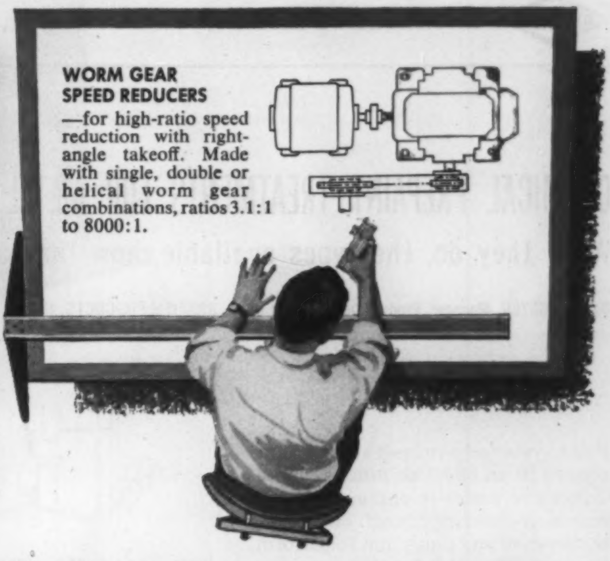


IN-LINE HELICAL GEAR SPEED REDUCERS

WORM GEAR SPEED REDUCERS



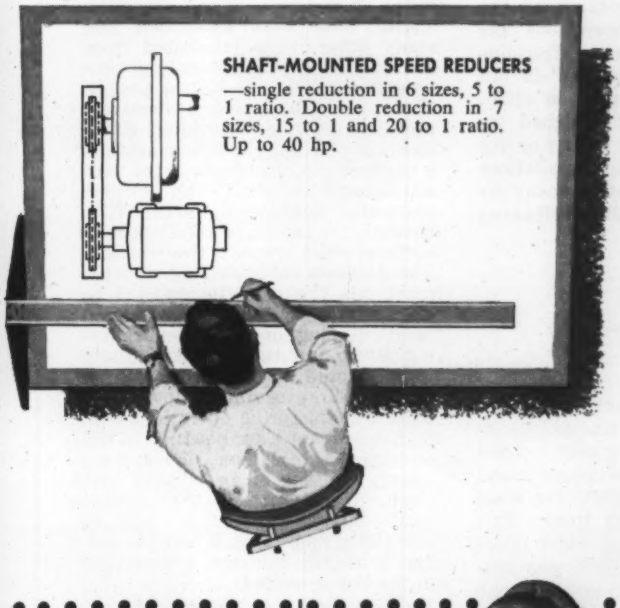
IN-LINE HELICAL GEAR SPEED REDUCERS
let you mount the motor where you want it. Save space with input and output shafts located on same planes. Ratios 6.2:1 to 2217:1, capacities to 206 hp.



WORM GEAR SPEED REDUCERS
—for high-ratio speed reduction with right-angle takeoff. Made with single, double or helical worm gear combinations, ratios 3.1:1 to 8000:1.

that's why LINK-BELT speed reducers

your layout



SHAFT-MOUNTED SPEED REDUCERS
—single reduction in 6 sizes, 5 to 1 ratio. Double reduction in 7 sizes, 15 to 1 and 20 to 1 ratio. Up to 40 hp.

Yes, you can plan with full freedom when you rely on LINK-BELT. *Seven* basic types of speed reducers—each in a wide range of sizes and ratios—give you complete flexibility in drive layout. It's easy to select the one that *exactly* meets your requirements for ratio, space, shaft position, shock loading and other specific factors.

And Link-Belt's leadership in speed reducers extends to every area of power transmission equipment. Link-Belt makes all related drive components—chain and sprockets, bearings, couplings—all dimensionally correlated with these reducers. This one-source responsibility eliminates need to exchange drawings with other suppliers and assures a matched set of equipment.

For full facts on Link-Belt's comprehensive line of speed reducers—including selection and features data—get in touch with your nearest Link-Belt office.

LINK-BELT

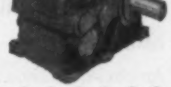
SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

UNIVERSAL WORM GEAR SPEED REDUCERS

SHAFT-MOUNTED SPEED REDUCERS

PARALLEL SHAFT SPEED REDUCERS



QUICK DELIVERY FROM STOCK.
Distributors, backed by 16 warehouses strategically located throughout the United States, assure immediate availability of all popular sizes of Link-Belt speed reducers.

15,148

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(Advertisement)

AMCHEM Information Bulletin

CHEMICAL PREPAINT TREATMENTS FOR METAL SURFACES

What they do, the types available, how they are applied

By J. H. GEYER, Manager, Product Development Dept., AMCHEM PRODUCTS, INC.

Paint systems have been steadily improved in an effort to produce more decorative, easier-to-apply, and more corrosion-resistant films. The ability, however, of any paint film to perform its predetermined functions cannot be fully utilized without properly preparing the metal surface.

Chemical *prepaint* treatments are designed to do four jobs and do them well. First, they remove organic soils, shop dirt, scale, and rust or corrosion products from the metal surface. Second, they provide surfaces that are completely compatible with subsequent paint films. Third, they produce a *tooth* that promotes good paint film adhesion. Fourth, they effectively prevent underpaint corrosion growth after any breakthrough in the paint film.

Basically, there are four types of chemical prepaint treatments—phosphoric acid, iron phosphate, zinc phosphate, and amorphous phosphate or chromate.

Phosphoric Acid—Phosphoric acid cleaner combination materials are an example of economical chemical prepaint treatments. Amchem Deoxidine is such a material. It removes organic soils, rust, scale and contaminating elements from the metal surface. It also produces a light etch on steel, aluminum or zinc surfaces which considerably aids in increasing paint adhesion. It does not, however, form an actual coating on the metal surface. Any breakthrough in the subsequent paint film will permit underfilm corrosion to proceed. Grades of Deoxidine are available for application by brush or swab, hot and cold dip, or hot spray.

Iron Phosphate—Iron phosphating processes are extensively used in the chemical prepaint treatment of appliances—water heater shells, ranges, washers, dryers and other *white lines*. These processes will produce excellent paint-bonding films on the metal and retard or prevent underpaint corrosion. Duridine, Amchem's iron phosphating process, is a combination organic soil cleaner and iron phosphate coating material. Both the cleaning and coating operations take place in the same bath. Duridine and other iron phosphates do not lend themselves to brush-on application, are primarily designed for spray type equipment of four or five stages. But several dip installations are successfully operating today by inclusion of an alkali precleaning stage.

Zinc Phosphate—Amchem Granodine is an example of zinc phosphating, the type now being used to treat steel in the automotive industry, and predominantly specified for steel ordnance and military items. This process forms a coating which offers the ultimate in paint adhesion promotion and vastly augments the corrosion resistance of subsequent paint films. Zinc phosphate materials are extremely flexible as to method of application—can be applied by brush, dip or automatic spray equipment. In a typical dip or power spray system, the stages would be alkali clean, water rinse, zinc phosphate treatment, water rinse, acidulated final rinse. If the metal has considerable areas of rust or scale, an acid pickle is advisable following the alkali cleaning stage.

On zinc surfaces, the zinc phosphates perform a rather unique function. They act as a barrier against chemical reaction between the applied paint film and the zinc surface. This effectively prevents blistering of the paint and early breakdown of the film. This is in addition, of course, to the improvement of paint adhesion and the retarding of underpaint corrosion. Amchem Lithoform is specially designed for use over zinc surfaces and finds wide application as a prepaint treatment for ornamental zinc die castings, refrigerator liners, and on most galvanized work requiring painted finishes.

Amorphous Phosphate and Chromate—These coatings are the films produced by the Amchem Alodine processes and similar ones on aluminum surfaces. They have met with wide acceptance in the prepaint treatment of venetian blind strips, refrigerator liners, aluminum heat transfer units, aircraft sheet metal assemblies, and many other items fabricated from aluminum. The various coatings provide an excellent film for the promotion of paint adhesion and effectively prevent underfilm corrosion. As in the case of zinc, aluminum exhibits a tendency to chemically react with some paint systems. The Alodine processes develop a barrier film between the paint and the aluminum surfaces which prevents this reaction. The Alodines are extremely versatile materials that can be applied to aluminum surfaces by brush, hand spray, dipping, or mechanical spraying. Brush application is particularly well adapted to the processing of parts too large for simple dip systems or in manufacturing operations that do not warrant a tank setup. In dip or spray application, the system usually consists of an alkaline preclean, a water rinse, the Alodine treatment, a water rinse, and an acidulated final rinse. Where the surface is heavily oxidized, a deoxidizer in the line is needed.

For more complete information about any one or all of these chemical conversion coatings, contact an Amchem sales representative or write us at Ambler 00, Pa.

AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)
AMBLER 18, PA. • Detroit, Mich., St. Joseph, Mo., Niles, Calif., Windsor, Ont.

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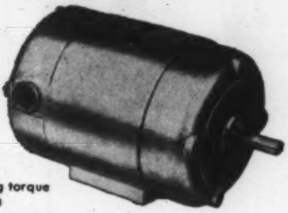
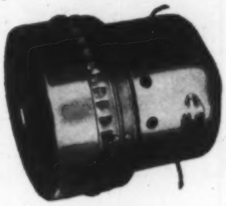
you get the RIGHT Motor...



Elevator door operating torque motor. Frame $3\frac{1}{16} \times 1\frac{7}{8}$

Four-pole permanent split capacitor motor for business machines. Frame $2\frac{1}{2}$ square $\times 1\frac{3}{4}$



$\frac{9}{16}$ Horsepower two-stage "by-pass" unit (motor separately ventilated) for light duty commercial vacuum cleaners.

Gearmotor with one spur gear and one worm gear stage giving right angle drive for business machines. Frame $3\frac{3}{16} \times 1\frac{3}{8}$

for your power-driven product with

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

You get the *right* motor to assure the product performance desired . . .

You get the *right* motor to meet weight and space requirements . . .

You get the *right* motor cost-wise, too, because . . .

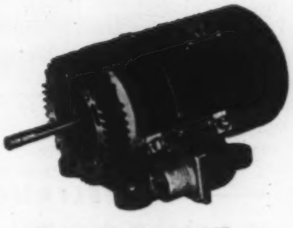
Lamb Electric motors are *engineered* to the application and *mass-produced* to obtain the most favorable cost.

May we demonstrate these advantages of our nearly half-century of experience in the small motor field?

THE LAMB ELECTRIC COMPANY
Kent, Ohio
A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric
Division of Sangamo Company Ltd.—Leaside, Ontario

NEW!

8-page Folder describes these and other Lamb motors. Send for your copy.



Totally enclosed fan-cooled 27 volt DC motor for dry air pump drive. Frame $3\frac{1}{4} \times 1\frac{5}{8}$

Two-pole 60 cycle AC motor incorporating propeller fan and high speed blower driven through step-up gear train. Frame $4\frac{1}{8} \times 1\frac{1}{4}$

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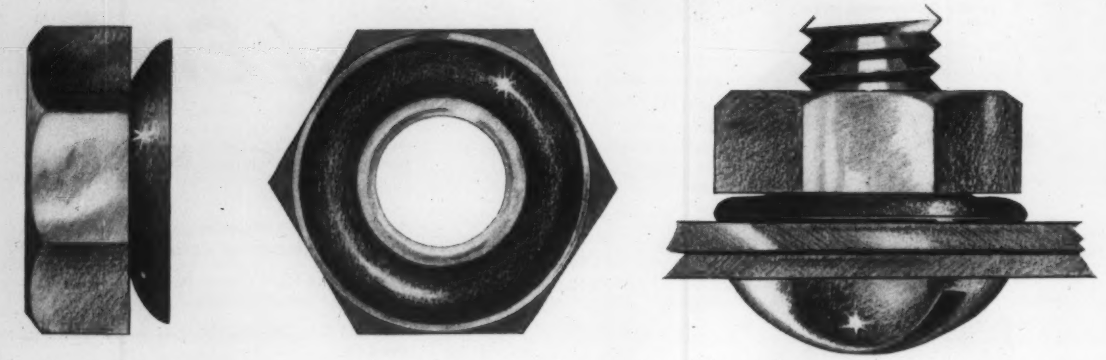
NEW TENZ-NUT®



preassembled for fast production . . .

Now — a spring washer preassembled on a hex nut — to save time in all types of assembly operations where the tested principle of bolt, nut and spring washer are required. Developed by Eaton-Reliance, this new fastener is now available for production use.

The spring washer — a modified Belleville, or "cupped" type — is firmly attached to the hex nut, yet it spins freely during application and removal. Tenz-Nuts are reusable.

The proven locking principle of the cupped-type washer, when combined with a hex nut, gives you a versatile fastener for automatic assembly operations. It is particularly applicable where finished parts are being assembled and it is desirable to minimize surface marring. Tenz-Nuts may also be adapted as sealing nuts.

Write for our new Engineering Bulletin which fully describes Tenz-Nuts.

Eaton also offers a complete line of Keps® — hex nuts preassembled with tooth-type washers. Our fastener engineers will gladly consult with you on possible applications on request.

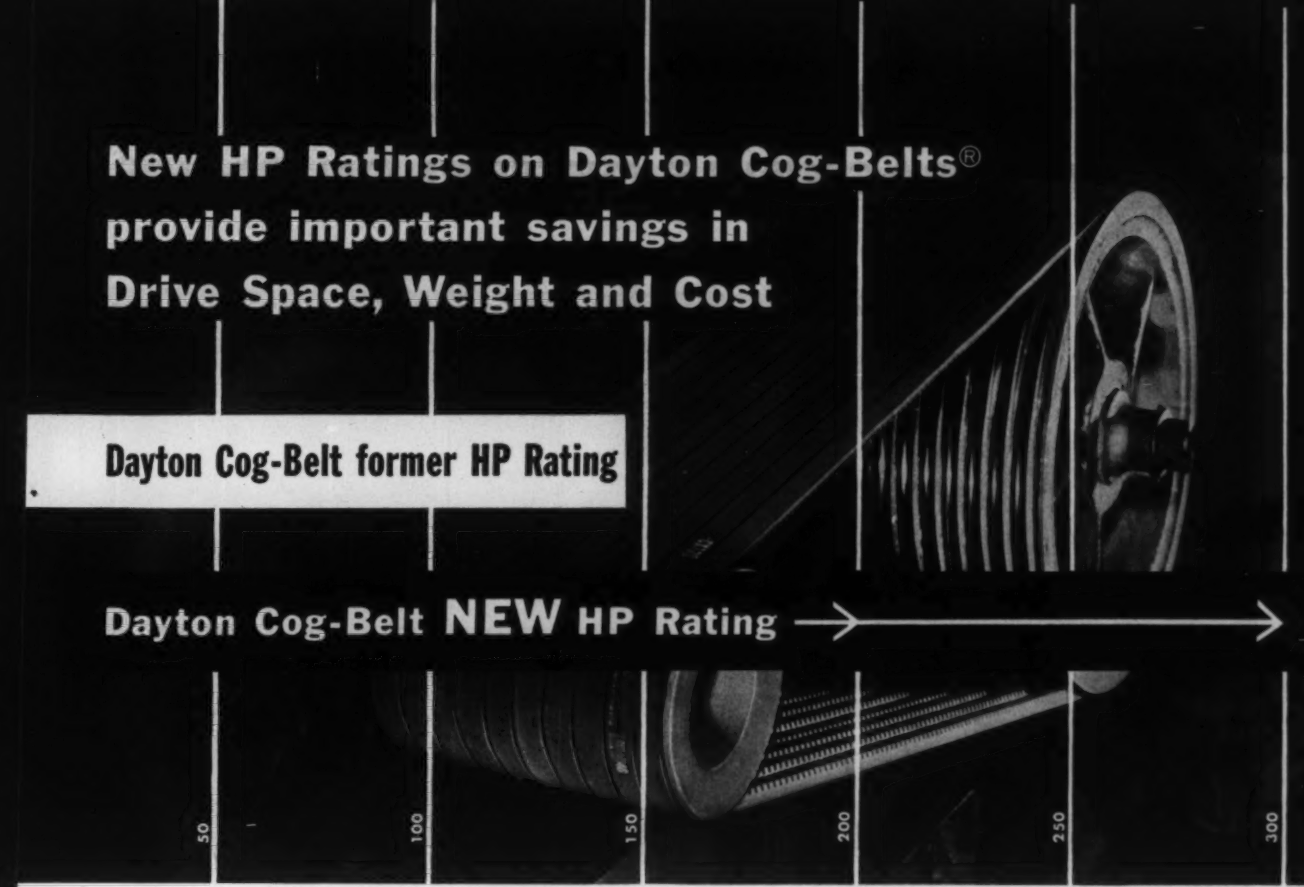
EATON®

RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Los Angeles

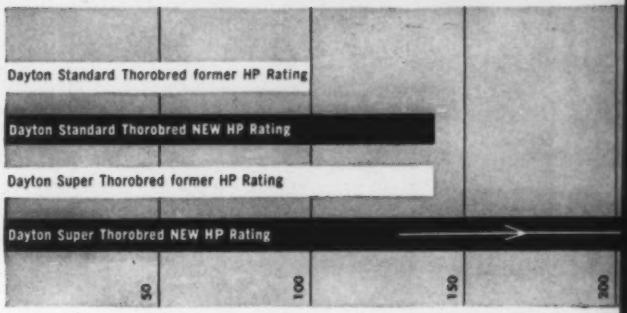
Circle 443 on Page 19

New HP Ratings on Dayton Cog-Belts® provide important savings in Drive Space, Weight and Cost



Dayton Cog-Belt Horsepower Capacity increased to 200-300% of previous Standard Belt Ratings . . . using existing industry-standard sheaves

- Two Cog-Belts do the work of as many as 6 previous standard V-Belts.
- No special sheaves required . . . use existing sheave stocks on Cog-Belt drives.
- Job-proven Dayton quality is backed by the experience of many actual drive applications throughout industry.
- New ratings approved only after proven by most rigorous research standards.
- Your present sheave inventories cover a much greater range of horsepower capacities.
- Less belts per drive mean less drive space, less drive weight.



Thorobred and Super-Thorobred V-Belts also newly rated

- New Thorobred ratings are now 140% of previous standard belt ratings.
- New Super-Thorobred ratings are now 170-220% of previous standard belt ratings.

Write for new brochure showing how designers can calculate Dayton Cog-Belt drives by referring to existing drive selection tables in Dayton's #208-B Handbook of V-Belt Drive Design. See "Belting" in the yellow pages of your telephone directory for the name of your nearest Dayton Distributor, or write Dayton Industrial Products Company, Division of The Dayton Rubber Company, Dayton 1, Ohio.

Utilize over 30 years of time proven Dayton quality, research and engineering in your V-Belt drive design.

Dayton Industrial Products Co.

A Division of The Dayton Rubber Company, Dayton 1, Ohio

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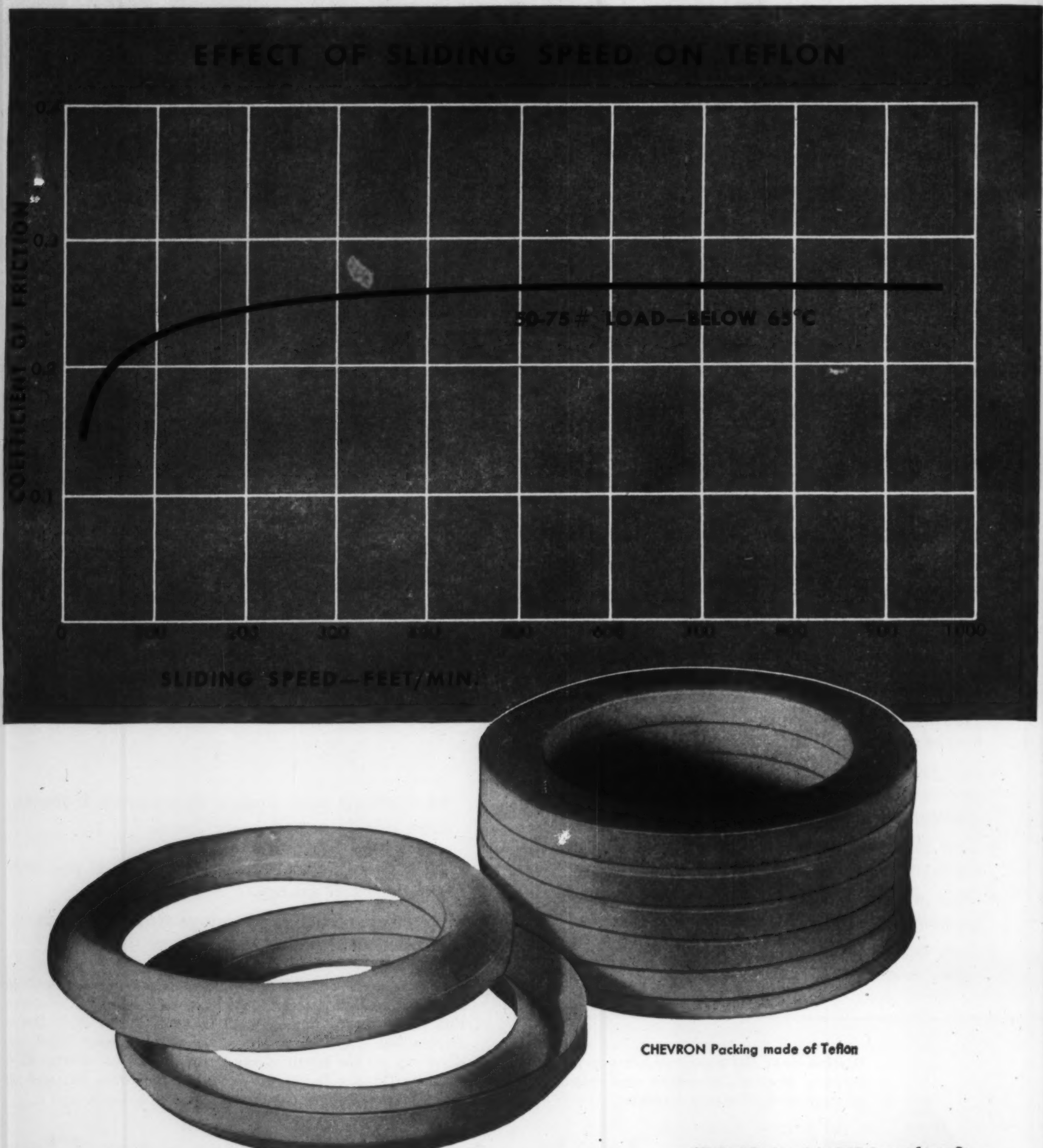
Wherever fluid power is used—

GARLOCK PACKINGS OF TEFLON* MAKE



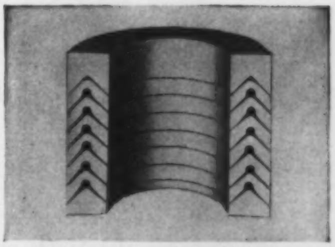
CHEVRON Packing made of Teflon

**DuPont Trademark for TFE fluorocarbon resin*
‡Registered Trademark

A BIG DIFFERENCE IN EFFICIENCY

FRICTION AND WEAR—enemies of top performance anywhere—can be held to the absolute minimum on all hydraulic and pneumatic applications if you specify Garlock CHEVRON‡ Packings, "V" Rings, "O" Rings, or Molded Cups made with Teflon.

CHEVRON PACKINGS of solid Teflon—or coated with Teflon—are as close to "frictionless" as you'll find. First of all, Teflon has the lowest coefficient of friction of any solid material in use today. Moreover, the CHEVRON itself is designed to permit free operation with minimum friction at all pressures. Here's how: with increasing pressures, CHEVRON packing rings tighten to prevent leakage. As pressures decline, the rings instantly ease off, permitting free operation of the rod, ram, or piston without leakage. This exclusive hinge-like construction (see illustration) lengthens packing life and, with proper initial adjustment of the gland, eliminates all further adjustments necessary to compensate for pressure variations.

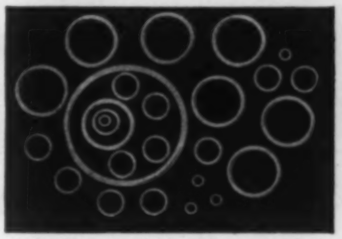


Exclusive hinge-like design adds to anti-friction feature of CHEVRON.

TEFLON "V" RINGS for higher pressures. Flexible enough to respond quickly to low gland and fluid pressures due to tapered "V" design.

"V" Rings . . . flexible, low friction seal at all pressures.

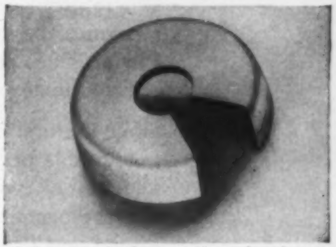
"O" RING PACKINGS made completely of, or coated with, Teflon provide exceptional anti-friction qualities on equipment where a round-bodied seal is required. And, to overcome the characteristic stiffness of solid Teflon rings, a new slotted Teflon ring is available to simplify installation in standard AN grooves.



"O" Rings . . less friction where round-body seals are needed.

TEFLON-COATED CUPS—the first advance in cup design in thirty years. Garlock has perfected a technique whereby cups are coated with a thin layer of Teflon which then becomes an integral part of the cup. Teflon-coated cups reduce breakaway torque, running friction, and completely eliminate "squealing."

OTHER FINE ADVANTAGES of Teflon packings: Solid-Teflon is chemically inert, tough non-flammable, resilient, long wearing. It can be applied against all hydrocarbons and new synthetic hydraulic fluids at temperatures ranging from −100° F to +500° F.



Teflon-coated Cups, reduce breakaway torque.

GET TOP EFFICIENCY through reduced friction and downtime. Discuss Garlock Teflon Packings with your local Garlock representative. He can recommend from the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Call him, or write for Catalogs AD-115 (CHEVRON Packings), AD-148 ("O" Ring Packings), and AD-145 (Molded Cups).

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Canadian Division: The Garlock Packing Co. of Canada Ltd.

Plastics Division: United States Gasket Company

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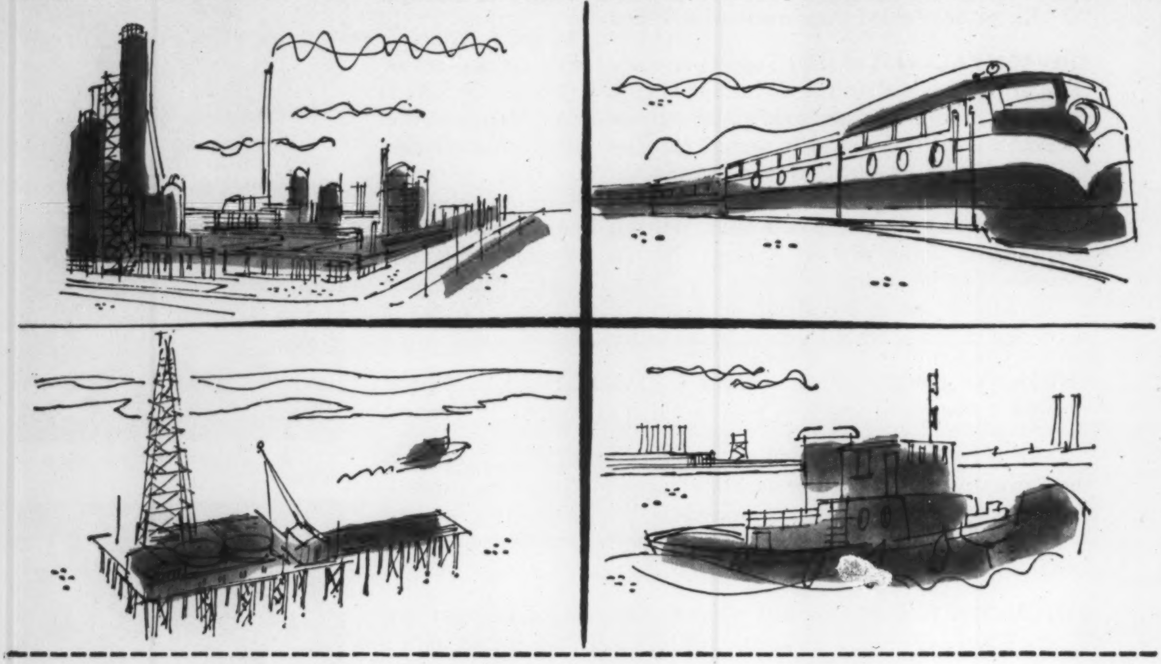
FOR THE LONG RUN . . .



it's KOPPERS Piston Rings

Where profit depends on keeping equipment in service, engineers recognize the importance of ring performance. That is why Koppers Piston Rings go into the finest engines in the world . . . why they are selected for replacement when better performance is demanded.

Since the first diesel engine, Koppers has produced piston rings of predictable performance in a complete range of materials and a wide selection of types and sizes. If you have a ring problem, Koppers can offer you the benefit of their experience. Write to: KOPPERS COMPANY, INC., Piston and Sealing Ring Department, 4506 Hamburg Street, Baltimore 3, Maryland.

Send now for Koppers recommended Piston Ring Set-Ups applicable to the engines which you operate.

KOPPERS

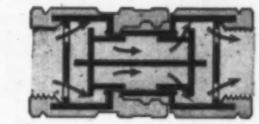
PISTON AND SEALING RINGS

Engineered Products Sold with Service

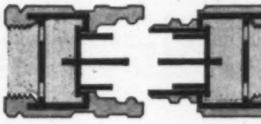
Hey, Herman... Snap-Tite valved couplings come in big sizes too!

There's a size and type to handle almost anything that flows

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly



DISCONNECT—No flow instantly

Snap-Tite can provide the right size valved coupling for most any use . . . with quick off-on action wherever coupling or shut-off is required.

"H" series valved couplings for high pressure applications. High resistance to heavy line surge. Sizes from 1/8" through 6". Larger sizes on special order.

"IH" series valved couplings for greater impact in air lines. 1/8" through 1/2".

"E" series valved couplings for vacuum and very low pressure. Recommended for gravity flow. Sizes from 1/8" to 6". Larger sizes on special order.

"T" series valved couplings for hard to handle fluids. The only valved quick-disconnect couplings now on the market for fluid temperatures from −40°F to +400°F. Sizes from 1/2" through 3".

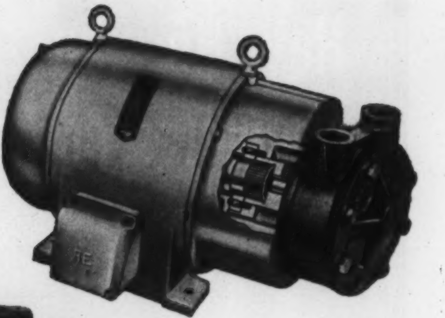
Snap-Tite valved couplings are available with two-way or one-way automatic line shut-off. They are normally furnished in alloy steel. Also available in brass, aluminum, or stainless steel with a variety of finishes.

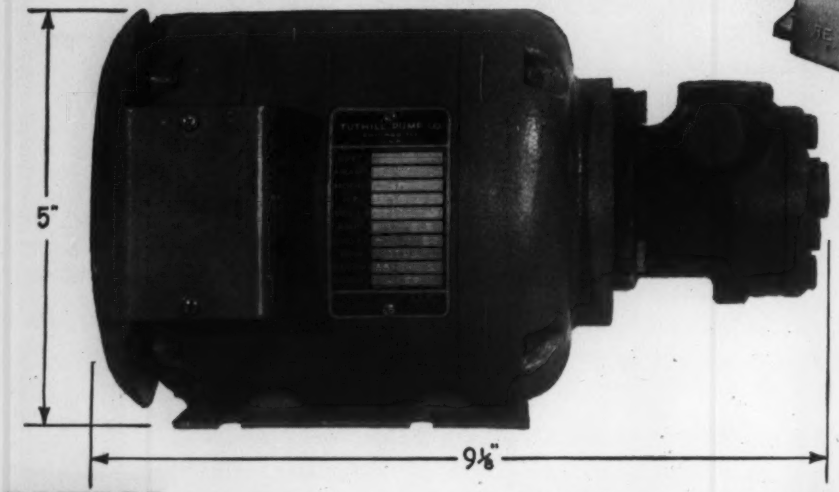
Write for Snap-Tite Catalog No. 58 for more information on Snap-Tite valved couplings.

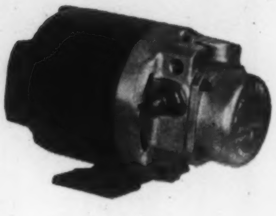
***Snap-Tite**

UNION CITY 11, PA.

ST-59-02







NEW pump & motor combination

adds to TUTHILL'S complete close-coupled line

The new Series 42 shown above further extends Tuthill's complete line of close coupled pump and motor units. These compact combinations have been especially developed to solve design problems and cut costs in hydraulic, oil burning, lubrication and a wide variety of other services.

As shown above, this compact new unit has overall measurements of only 9⅛" by 5". The totally enclosed motor is supplied with ratings of from 1/12 to 1/6 hp, while the pump units have a capacity of 1/3 to 3 gpm. The Series 42 may be supplied either with or without a built in relief valve.

Some other models in Tuthill's line of close coupled combinations are also shown above. These include a broad selection of units with capacities up to 50 gpm, for pressures to 400 psi.

Save space, weight and money

The compact design of these units solves tough design problems. The elimination of couplings, bases and adapters results in significant savings. The reduction of weight lowers shipping costs. And their compactness often simplifies assembly operations for further savings in production costs.

Available from stock

All the units shown above, plus many others are immediately available from stock. There is no minimum quantity requirement . . . so you can use these economical units in a wide variety of applications.

"POWERMITE" for OEM applications

For original equipment applications involving substantial production runs, Tuthill offers further savings in space and weight through the use of the POWERMITE. This is an exclusive Tuthill design in which pump and motor are incorporated into one unit, which takes up no more space and weighs no more than a conventional motor. For example, the Powermite shown at lower right above, measures only 8 1/6" by 4¾" . . . has a capacity of 16 gph at 350 psi.

Tuthill's engineers will be happy to develop a Powermite specifically designed for your OEM application . . . providing the greatest possible saving in space and weight.

If you are trying to incorporate a pump and a motor into a limited space Tuthill has the answer. An experienced Tuthill field engineer will be happy to give you the details. Write today.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Circle 448 on Page 19

CRIMP at bench...or at equipment

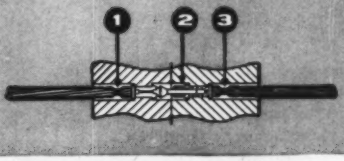
Precision hand, pneumatic, or automatic tooling guarantees uniform and complete crimp for each connection —a measurable quality control —at a high speed production rate.

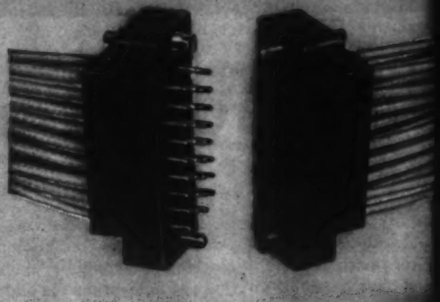
SNAP-LOCK ... in or out

Pins and sockets are easily and quickly snap-locked into plugs and receptacles. They may be removed with a simple extraction tool for circuit changes or checks.

CONNECT ... only 3 points of contact

The HYFEN method provides the minimum number of contacts—3—thereby reducing reliability problems. Exceeds the requirements of MIL-C-5015C and MIL-C-8384A.





ACCEPTED!
Hyfen Variations

ME rack and panel HYFEN connector. 8 or 26 place configuration. One-piece shell and one-piece block. Also available for coaxial or shielded cable.

Feed-thru, modular design, multiple insert connector. 45 contact inserts can be removed from frame for easy contact insertion or removal. 5 or 8 insert frames available.

Printed circuit connector in either 31 or 45 place configuration. Accommodates single wire or combinations of wire sizes.

HYFEN types illustrated are typical of those already supplied to the industry by BURNDY. HYFEN connectors are engineered to meet specific requirements. For other types or sizes, contact BURNDY.

HYFEN® connectors

with crimp-type snap-locked contacts

BURNDY's HYFEN method, already widely accepted in the industry, speeds the wiring of electronic harnesses and systems, and achieves greater dependability and versatility than has heretofore been possible. Crimp-type connections eliminate time-consuming solder operations and the disadvantages in the use of solder.

For complete information, write: OMATON DIVISION

BURNDY

59-3

Norwalk, Connect. **In Europe: Antwerp, Belgium** **Toronto, Canada**

Circle 449 on Page 19

WHY DID THIS BOLT FALL OFF?

Where is the culprit . . . the nut whose function was to keep the bolt securely in place? Undoubtedly it fell off earlier . . . loosened by vibration . . . or unexpectedly high shock loads due, perhaps, to a careless operator. In any event, the bolt was pounded into uselessness . . . and failed. Chances are that the equipment the bolt and nut were part of is temporarily useless too.

Why then, was an inadequate fastener applied in the first place? Perhaps because "bolts and nuts" are often overlooked or specified routinely. Perhaps to save a fraction of a cent. Whatever the reason, the end result was inefficient and uneconomical. The nut failed—the fastening failed—and the product failed.

It could have been prevented. An Elastic Stop® nut would have held on. The small extra cost of the *best* self-locking nut would have solved this case . . . saved repair bills . . . downtime . . . and a manufacturer's reputation.

For detailed photos showing how some of America's foremost manufacturers of heavy equipment have insured critical bolted connections with Elastic Stop nuts on such units as rock drills, scrapers, snow plows, off-the-road trucks . . . write to ESNA. Or, for first hand proof, tell us the preferred size and we'll send you test samples. Address: Dept. S35-64, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

DOUBLE DEPENDABILITY

The dependability built into every Elastic Stop nut builds itself into the dependability of every product on which it is used.

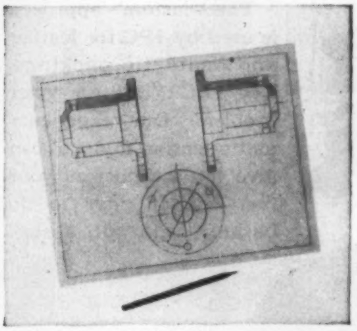
ELASTIC STOP NUT CORPORATION OF AMERICA

Some Ideas for your file of practical information on drafting and reproduction from KEUFFEL & ESSER CO.

A year of relentless testing has produced a small library of interesting facts about HERCULENE (T.M.) Drafting Film. What follows is a consensus of drafting-room experience with HERCULENE—by K&E and its customers—with some up-to-date recommendations for using it. Take the matter of . . .

Shiny Back vs. Pencil Back

A basic question is: do you need a double-surfaced drafting film? We make HERCULENE Drafting Film both ways, of course—with a single surface (shiny back) and double surface (pencil back). It's our recommendation that you use pencil back HERCULENE only if it's your practice to make basic drawings on one side, changes on the other. For most other uses, shiny back is preferable. (At first, the double-surface film was chosen by many drafting rooms because it lay flatter on the board than shiny back. This is no longer true. K&E research labs have come up with a fully effective anti-curl treatment.) Especially in filing, shiny back HERCULENE presents fewer problems. The clean non-abrasive back won't smudge the face of the sheet underneath, even in a heavy stack of tracings. If you'd like to compare a few sheets, please let us know.



Note sharp clear lines made by Duralar pencil on HERCULENE Drafting Film.

Plastic Pencils and the HERCULENE Surface

Not just a handy catch-phrase, when K&E puts its exclusive "engineered surface" on a drafting material, the result is an exact, uniform tooth for sharp pencil drawing, inking and typing. With HERCULENE Drafting Film, however, an entirely new type of plastic (non-graphite) pencil yields especially good results. Quite a few of our customers have reported favorably on the well-known Staedtler "Duralar" brand. Duralar pencils come in five hardnesses, are non-smudging and have generally good covering power, sharpness and erasability. After about 20 prints, the Duralar lines show up consistently better than those made by a regular pencil, since graphite lines tend to lose density.

Wet That Eraser!

The erasing qualities of HERCULENE Drafting Film are excellent, but (as with the pencils) we've discovered it's a new type of vinyl eraser that gives the best results. Examples of these non-rubber type erasers are the Richard Best "TAD" and the Eberhard Faber "RACE KLEEN"—both available from your K&E dealer. With vinyl erasers, pencil lines whisk off. Even stubborn ink and typing can be removed easily, with no damage to the surface. Here's a tip on how to do this:

Moisten the eraser slightly. It becomes no more abrasive, but a lot more "erasive." Moistening is a must when removing Duralar lines or typing after exposure to heat. (Incidentally, don't use electric erasing machines, steel erasers or typewriter erasers.) When erasing large areas, certain chemical eradicators work fine too. Our suggestion: use Vythene or a very light application of a denatured alcohol such as Solox, both of which can be applied with a cotton swab or clean cloth.

The Cleaner the Better

HERCULENE Drafting Film was designed for ink work, and its ink take is unexcelled. But like all films, its non-absorbency makes a few preparations advisable. The surface should be cleaned thoroughly before inking. Quickest and most effective way to do this is with the ABC Draftsman's Dry-Clean pad, which will remove finger marks and "traffic film" simply by rubbing the pad over the surface. Pouncing will also work well. A damp cloth is all right for general cleaning, but does not do the best job of preparing the surface for ink.

Inking over graphite pencil lines comes out best when done over light lines, drawn with a harder grade of pencil. A good way to remove excess graphite is to go over the drawing with an ABC pad. Inks vary in their usefulness on HERCULENE. We've tested several, and you're welcome to these results as well, on request.

After Typing, Please Pounce

Typed impressions on HERCULENE Drafting Film are crisp and sharp, but may take a while to dry because the film's surface doesn't "swallow" ink readily. A light pouncing right after typing will dry the ink and fix the lines—giving you uniform permanent contrast.

A new typewriter ribbon will produce the best impressions. At K&E we've tested a healthy variety of ribbons and we'd be pleased to send you the results on request.

Outstanding Advantages Proved in Tests

We're pleasantly amazed at the short time it took for HERCULENE Drafting Film to become an accepted "staple"—along with ALBANENE® Tracing Paper and PHOENIX® Tracing Cloth. Actually, it's a rare drafting room by now that has *not* tested HERCULENE during its first year on the market. The findings: All properties considered, HERCULENE stands up better than any other drafting film. It has great resistance to heat, aging and abuse. Its exclusive "engineered surface" plus its tough, durable Mylar® base provide superior pencil and ink take, fine erasability, remarkable dimensional stability...a combination we're proud to call unbeatable!

The K&E dealer near you has HERCULENE now. Stop in and see him.

KEUFFEL & ESSER CO., Dept. MD-6, Hoboken, N. J.

Please send further information about HERCULENE Drafting Film. I'd like samples too.

Name & Title ________________________________

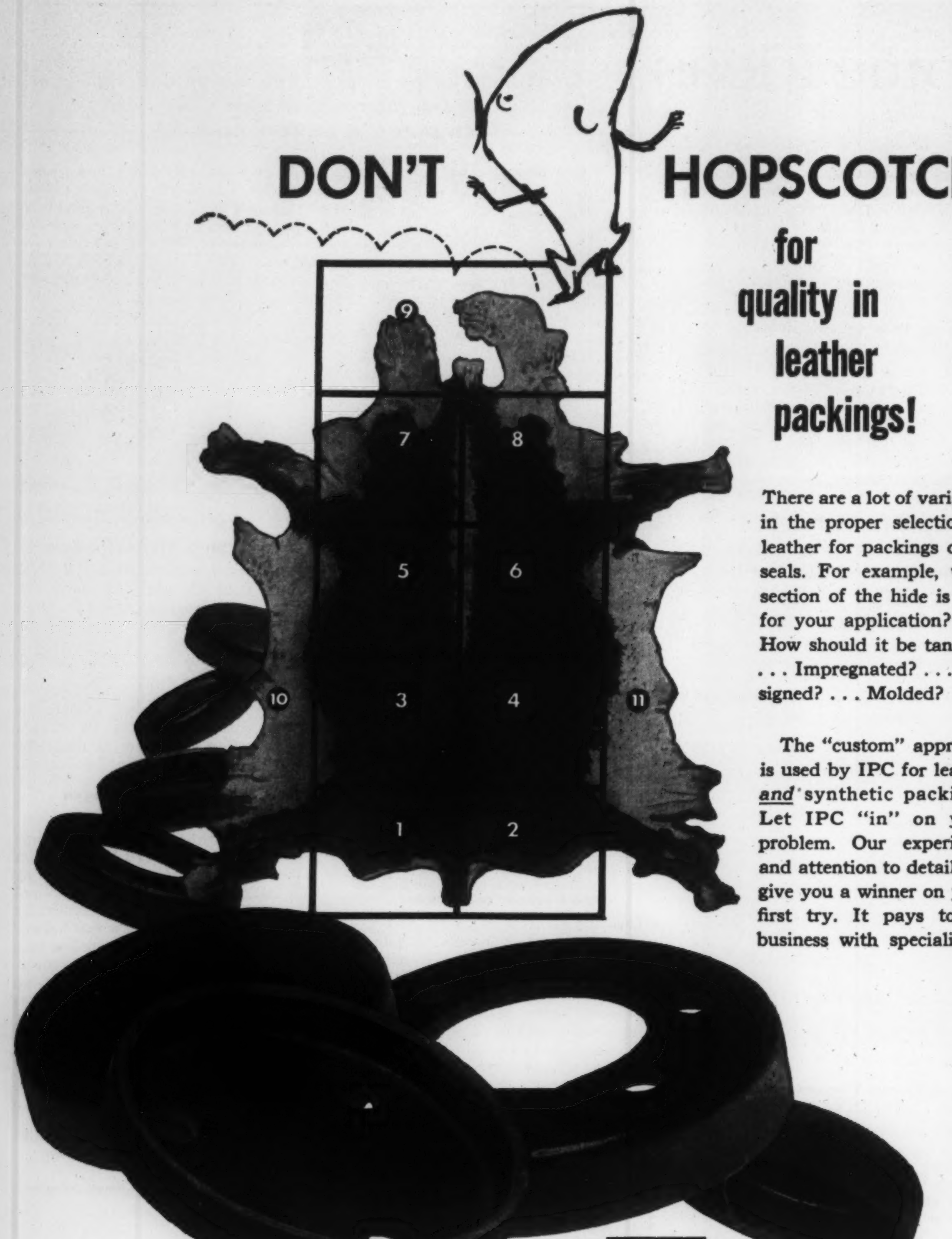
Company & Address ________________________________

____

2001

DON'T HOPSCOTCH

for quality in leather packings!



There are a lot of variables in the proper selection of leather for packings or oil seals. For example, what section of the hide is best for your application? . . . How should it be tanned? . . . Impregnated? . . . Designed? . . . Molded?

The "custom" approach is used by IPC for leather *and* synthetic packings. Let IPC "in" on your problem. Our experience and attention to detail can give you a winner on your first try. It pays to do business with specialists.

OIL SEALS
PACKINGS
PRECISION MOLDING
Custom designed
. . . for your application

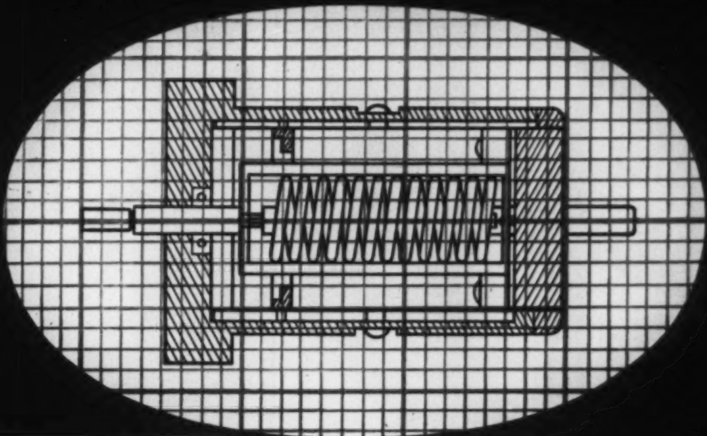
IPC

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire

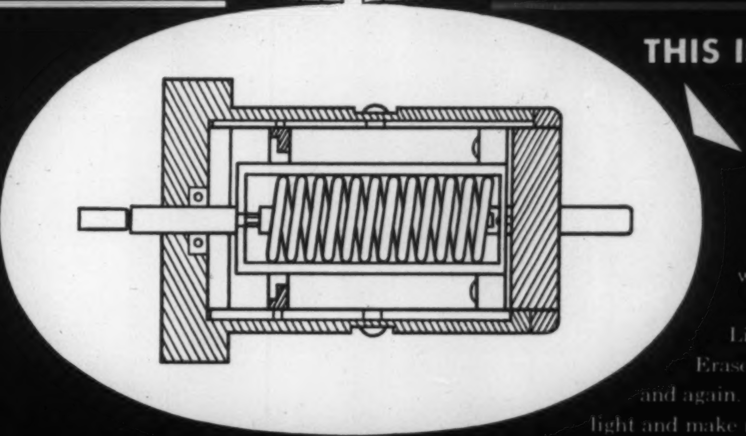
P4

When you specify

Drafting costs are cut in half



Quickly and accurately rendered to scale with blue grid lines to guide you. Guide lines are on back of drawing surface enabling you to erase and erase without disturbing them.



THIS IS YOUR PRINT

Blue grid lines have disappeared completely giving sharp, easy-to-read copies.

Try Clearprint's perfect working surface with a 2H pencil—then with a pen. Lines are sharp and clear—Erase and draw the lines again and again. Now hold Clearprint to a light and make reproductions. No ghosts! Then test your present sheet.

Ask our representative or write us regarding Clearprint's revolutionary new "Pre-Print" which pre-prints your basic standards, typical details, title blocks, and bills of material. Their application to your particular needs can save thousands of dollars in drafting and lettering time!

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☐ Please send me sample Clearprint "Fade-Out" sheets, with prices.
☐ Send me Clearprint samples, with prices, for the following uses:

☐ Have your representative call at my office to discuss special applications for my particular needs.

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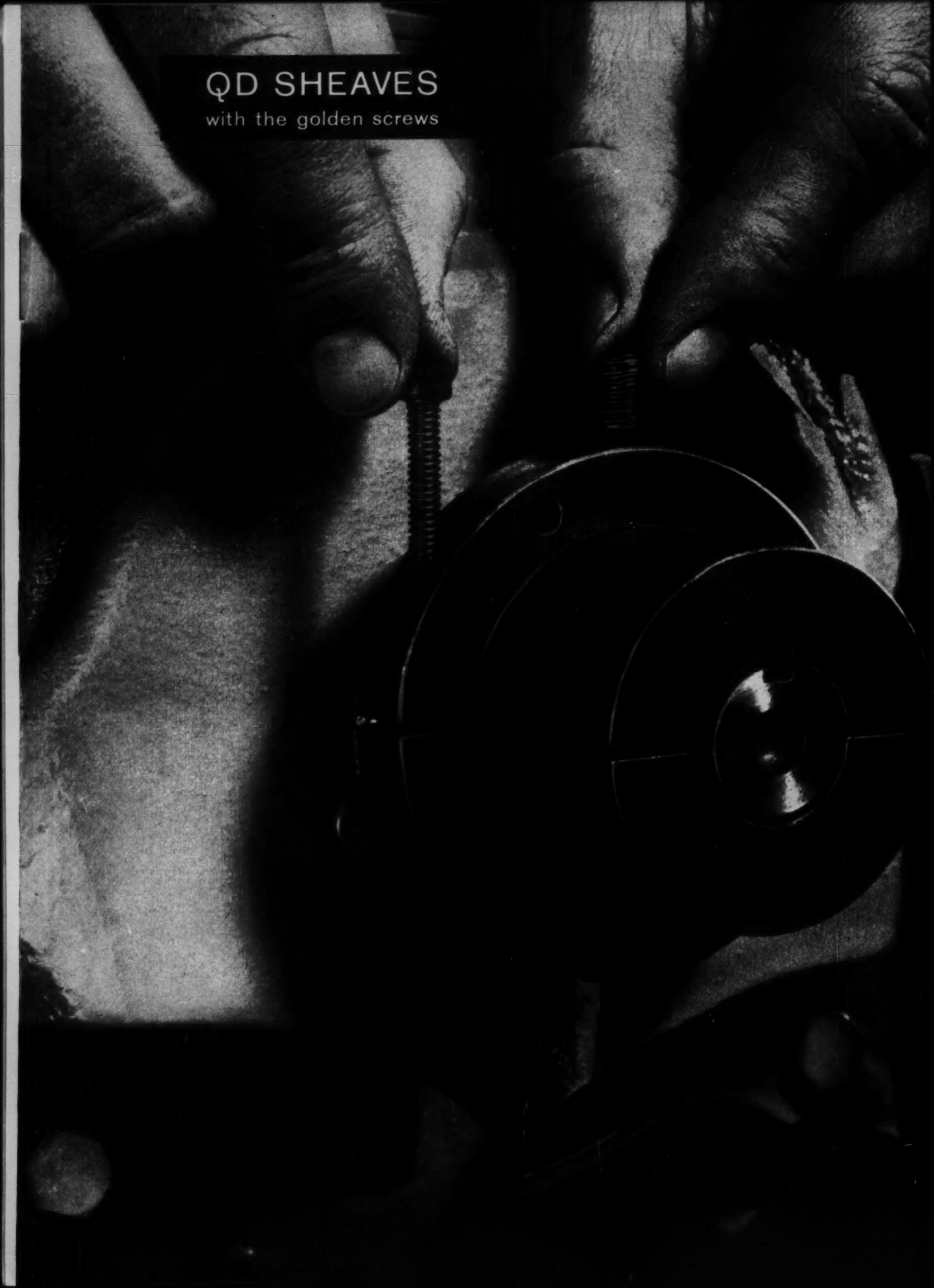

QD SHEAVES
with the golden screws

Announcing Worthington QD Sheaves with the

GOLDEN SCREWS

Golden screws? That's right. All Worthington QD (Quick Detachable) sheaves now have two golden screws. Worthington has a reason for doing this: to demonstrate to you that the exclusive two-screw design is practically worth its weight in gold. These extra two screws are the big difference in sheaves.

The clamp screw simplifies installation and assures permanent alignment. You can install QD sheaves *one part at a time*. No heavy rim and hub combination to delicately inch into place. You just slide the hub on the shaft and permanently lock it in position with the clamp screw. Then you slide the sheave rim into position on the hub. This job is simplified because you engage the large end of the sheave with the small end of the hub. To change speed you simply install another sheave on the hub which remains anchored to the shaft by the clamp screw.

The set screw prevents "key drift." It locks the key securely in place, avoiding the danger of the key drifting off and becoming a safety hazard. This feature is appreciated by plant operators who first brought this potential danger to Worthington's attention.

You tighten the set screw without distorting the hub. The clamp screw allows you to locate the hub on the shaft. The locked hub then permits you to tighten set screw on key without distortion.

You can get Worthington QD sheaves anywhere in the U.S. More than 350 distributors carry Worthington sheaves and Worthington-Goodyear Green Seal V-belts. For your copy of a 100-page Multi-V-Drive Manual on how to select the right sheave and V-belt write to Worthington Corporation, Section 79-15, Oil City, Pa. In Canada: Worthington (Canada) Ltd., Brantford, Ont.

WORTHINGTON

Clamp screw locks hub to shaft for permanent alignment. Hub is locked in one piece—*no distortion* as set screw is drawn down.

Set screw locks key in place, prevents "key drift," a necessary safety feature.

Pull-up bolts lock the sheave rim to the hub.

Circle 454 on Page 19

titeflex flexible hose made for the toughest design jobs

It is now possible to design fluid transfers that would have been impossible until recently. Here are examples of TITEFLEX advances in the flexible hose field:

ITEM: Springfield "400"* Teflon** hose in diameters to 2" . . . convoluted by an exclusive process to produce unique flexibility . . . minimum bend radius only 3⅓ times hose diameter!

ITEM: "Zero-motion" braiding . . . a TITEFLEX process that also reduces chafing of braid wire, and wear to minimum. Elongation or contraction at operating pressure less than ½ of 1%!

ITEM: Springfield "140" Teflon Hose Assemblies . . . with reusable fittings . . . factory or field installed!

ITEM: Springfield "110" Teflon Hose Assemblies . . . guaranteed against fitting blow-off at their specified temperatures and pressures!

TITEFLEX is found wherever design problems are toughest. Details and specifications are as close as your phone. Your TITEFLEX distributor is in the yellow pages, or contact TITEFLEX direct.

titeflex

**T.M. of Titeflex, Inc., Patent Pending* ***Reg. T.M. of duPont*

titeflex inc. springfield mass. PACIFIC DIVISION • SANTA MONICA • CALIF

why use 19th century metals to carry 20th century loads?

for solid bearings, Alcoa Aluminum far outperforms old-fashioned metals ...and costs far less. Here are the facts:

DESIGNERS of a century and more ago *had* to rely on bearings of babbitt or bronze; better bearing metals just didn't exist.

BUT WHY should *you?* Not *cost*, certainly, for a typical aluminum alloy bearing sleeve costs as much as one-third less than other materials.

PERFORMANCE? Solid aluminum bearings support up to 10,000 pounds per square inch. Years of service in a host of applications from railroads to rolling mills show ability to stand up long after inferior metals have failed. Aluminum bearings run cooler—as much as 20° by actual test—because *no* other bearing metal is as good a heat conductor.

AND ALUMINUM bearings *last longer*, because they conform, thanks to aluminum's famous ductility. Because of aluminum's famed resistance to corrosion, especially to additives in lubricating oils. Because it embeds gritty particles that might cause abrasive wear and scoring. Because of their lower frictional resistance under heavy load, aluminum bearings permit immediate starting.

SO WHY rely on old-fashioned bearing materials? *Design around aluminum*—for maximum flexibility, optimum performance, minimum cost.

For further details, call your nearest Alcoa sales office, or write: Aluminum Company of America, 1837-F Alcoa Building, Pittsburgh 19, Pa.

Aluminum Bar Stock Now Available Locally!

Your nearby Bunting Distributor can now quickly fill your replacement bushing needs with cost-saving, high-performing Alcoa® Aluminum bars. He carries a complete line of 138 different sizes in solid and cored aluminum bar stock.

Call your Bunting Distributor for Alcoa Aluminum bars and save as much as 33⅓ per cent on your replacement bushing costs.

ALCOA
ALUMINUM
ALUMINUM COMPANY OF AMERICA

Your Guide to the Best in Aluminum Value

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

Another Tinnerman Savings Story...

Easier, faster, better, cheaper...4 reasons to use SPEED GRIP® Nut Retainers

Easier ... because anyone anywhere on the J. I. Case tractor production line can snap the spring steel retaining legs of the SPEED GRIP into punched panel holes. No special skill required. Hole alignment is no problem — the nut "floats" inside the cage to compensate for normal tolerances in the parts being assembled.

Faster ... no staking, no welding. No retapping of paint-clogged threads because SPEED GRIPS can be applied *after* painting. And they pop quickly and easily into position for final assembly.

Better ... heavy-duty SPEED GRIPS make possible sturdy, reliable attachments because both the cage and the nut are made of high quality steel. In case of accidental cross-threading, the SPEED GRIP can easily be replaced. You never have to "make do" with a sub-strength fastening.

Cheaper ... J. I. Case estimates a savings of about 30% per fastener over the previous method.

Want to achieve these benefits of SPEED NUT Brand Fasteners for your product? Refer to your Sweet's Product Design File, section 7-Ti, then call your Tinnerman representative (listed in most Yellow Pages under "Fasteners"). Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®
FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. **GREAT BRITAIN:** Simmonds Aerocessories Ltd., Treforest, Wales. **FRANCE:** Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). **GERMANY:** Mecano-Bundy GmbH, Heidelberg.

IMPACT VS. PLASTIC LAMINATES

It's more than
"How Much"
and "How Often"

It is easier to picture impact than to describe the effects of it upon plastic laminates such as Synthane. For one thing, impact is measured in several ways. In the standard A.S.T.M. (Izod) test notched samples ½" x ½" x 2½" are struck by a pendulum. This test is an accepted standard yet it seldom measures the impact behavior upon plastic laminates. Reason: certain grades of laminates are "notch sensitive", a condition which they may never meet in a practical application.

Nor does the Izod test indicate the ability of Synthane to resist repeated blows. Figure 1 shows how many times blows of a pre-determined intensity can be absorbed before the material breaks down.

Temperature Affects Impact Strength

Even repetitive impact is not the whole of the story. Temperature has an interesting effect upon impact strength (Izod). The curves in Figure 2 show that at extremely low temperatures glass-base grades of Synthane actually improve in impact strength, while other grades improve as they are warmed. The impact strength of Glass Epoxy Grade G-10 improves sharply at temperatures above 75° F.

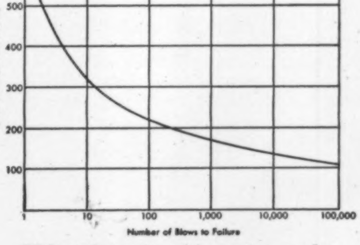


FIG. 1 Intensity of impact vs. cycles

Impact Rarely Travels Alone

Like so many other properties of laminates, impact strength can rarely be regarded alone; it must be related to other properties required for the application. A sheet of Synthane has less impact strength than an equal thickness of steel. But steel is over seven times heavier and is a conductor, not an insulator. It is the combination of other properties desired, including impact strength, that is decisive.

Typical applications for Synthane's combined properties under impact conditions are (a) Grade LE Synthane in the shock struts of Airplane Landing Gear (light weight, low coefficient of friction, compressive strength, wear and shock resistance); (b) Welding Tong Insulation, made from G-5 Synthane (high resistance to impact, excellent resistance to heat, and good dielectric strength); (c) Ignition Breaker Arms of Grade C molded-laminated Synthane (impact resistant, wear resistant, dielectrically strong).

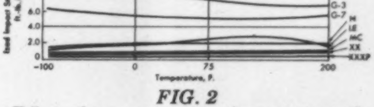


FIG. 2
Effect of temperature on impact strength

If you have any question about the selection of the proper grade of Synthane for your impact application refer it to us directly or to a Synthane representative. Make sure you obtain the most of what you want for the money. For information write Synthane Corp., 5 River Road, Oaks, Pa.

Synthane laboratory machine for measuring impact fatigue.

SYNTHANE
CORPORATION, S OAKS, PENNA.
Laminated Plastics for Industry
Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

Circle 458 on Page 19

How to hang 40 tons of beer from the ceiling

These vessels, called "Dual-Paraboloid" fermentation tanks, are shaped like giant toasters. They're 21 feet long, 13 feet high, and 12½ feet at the widest point. Solar Chicago, Division of U.S. Industries, Inc., makes them from 13-gage Type 304 Stainless Steel sheets that are curved and welded together to form a cornerless interior. 1″ x 4″ ribs are welded around the outside of the tank and all welds are ground to a uniform finish.

Each of the tanks will hold 450 barrels, more than 40 tons, yet the tanks themselves are so light that the entire load will be hung from the ceilings of modern breweries. The formability, weldability and strength of Stainless Steel permitted this unique design. Because the Stainless is so strong, they could use thinner, *lighter* walls.

These tanks weigh 5 tons and they will replace old, square-cornered ones that weighed about *20* tons. Breweries are happy . . . the cornerless, Stainless tanks are easier to keep clean, and because they're off the floor, the plant itself stays cleaner. And because they're Stainless Steel, they will probably never have to be replaced.

USS is a registered trademark

USS

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

MOYNO®
PUMPS

Let MOYNO'S® *"Progressing Cavities"* Cut your Pump Maintenance Costs!

MOYNO's unique *"progressing cavity"* principle cuts pump maintenance costs because material being moved contacts only one moving element. MOYNOS are constructed to stoutly resist corrosion and abrasion. As shown in the cutaway model above, MOYNO's screw-like rotor revolves in a double-threaded stator forming *"progressing cavities"* that move material smoothly along, without foaming, aerating or crushing. Even where duty is so torturous that rotor and stator must be made of special resistant materials, MOYNO parts show little wear.

In industry everywhere, and on OEM applications, MOYNOS are proving "if it can be pushed through a pipe . . . MOYNO will pump it!" Typical materials pumped include non-pourable pastes, abrasive slurries, chemicals, foods, acids, even suspended solids up to one inch in size. Many materials now successfully pumped by MOYNO were once considered "unpumpable" . . . had run up prohibitive maintenance costs on other type pumps or ruined them completely.

Capacities are available up to 500 gpm and pressures up to 1000 psi. Off-the-shelf replacement parts are always immediately available. No doubt your plant flowsheet or OEM product has a spot where MOYNOS can cut costs drastically. To find out how, write today for Bulletin 30 MD

capacities to 500 gpm; pressures to 1000 psi

ROBBINS & MYERS, INC.
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps
SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Phenolic for a rocket motor**
- **Heat-stable, moisture-stable insulation**
- **Compounds for dip coating**

REDSTONE DIV., THIOKOL CHEMICAL CORP.

It's warm in there

That's the exhaust pattern of a solid-propellant rocket motor. Temperature inside sometimes hits 6000°F.

At the nozzle, fuel-burning releases its full fury. To keep the bird's metal skin from buckling under the combined heat and stress, rocket engineers line many nozzles with a glass-reinforced phenolic, *Durez 16771*. During flight this plastic liner chars—at a predictable rate. It protects the metal nozzle wall from thermal failure.

Equally dramatic, if less spectacular, are the design improvements that *16771* is making possible because of its impact strength (up to 15 ft.-lb./in. Izod) and other properties. One manufacturer molds it into a rugged pump base that won't corrode and that outwears many metals. The U. S. Signal Corps puts its strength to work in boxes that protect the parachutes on droppable radios. Automotive engineers save two-thirds of the cost of automotive oil-pump gears by replacing metal with *16771*—and get gears that run almost three times as long as before.

New bulletin: To help you evaluate *Durez 16771*, we'll be glad to send you Bulletin D203. It gives a good idea of the properties you can expect, discusses current applications, and includes helpful advice on molding, machining, and finishing. If you'd like a copy, just check the coupon.

Insulation at close range

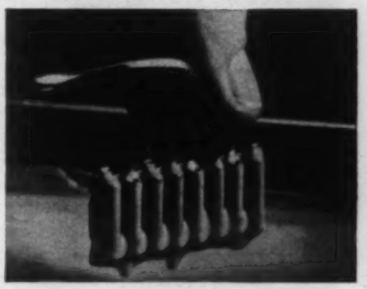
The push for good, compact insulating materials grows stronger. More electronic engineers are cramming more performance into fewer cubic inches than ever before. Under these conditions, cost of an insulator means little—when a pound of the *right* one will make smaller components, and perhaps twice as many of them.

Such a material is *Durez 16694* diallyl phthalate molding compound. We believe it to be the cream of the current plastics crop for molding components and larger parts in which circuits must function with sterling reliability despite heat, moisture, electrical and mechanical stress, and narrow working quarters.

This orlon-filled compound molds well, is not brittle, machines easily with little wear on tools. Its molding characteristics are unvarying from shipment to shipment.

It produces pieces that have very high arc resistance, consistently reproducible. It retains dimensional stability and high insulation values over extended periods at relative humidities above 90%. It does not corrode metal contacts and is virtually free from cold flow and creep.

Durez Bulletin D400 lists the properties of this compound and other electrical-grade materials. The data sheet on *Durez 16694* diallyl phthalate goes into detail on electrical test results. To get both pieces, check the coupon.



Helping resistors resist

Problem: Find a coating material that keeps tiny components like these protected against humidity—and won't peel back under the heat of a soldering gun.

Solution: A dip-coating compound based on Durez phenolic resins.

This thermosetting compound goes on smoothly without running or sagging. It's just porous enough to take a protective wax sealing coat. It cures hard, to allow stamping or color coding. It doesn't migrate or peel back during soldering.

Durez research men worked closely with electronic engineers for more than seven years to develop compounds like this. Improved each year, Durez dip-coating compounds are the most widely used of their type. A check mark on the coupon will bring you specifics about them.

For more information on Durez materials mentioned above, check here:

☐ *Durez 16771*, impact phenolic (Bulletin D203)

☐ *Durez 16694*, diallyl phthalate (Bulletin D400 and data sheet)

☐ Phenolic resin compounds for dip coating

☐ "Durez Plastics News," mailed periodically, shows and describes latest uses of Durez materials.

Clip and mail to us with your name, title, company address. (When requesting *samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION
506 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER
CHEMICALS
PLASTICS

NEW HIGHER PERFORMANCE FOR FORMCHROME* SPRAGS

On over-running clutch applications, Formsprag clutches have always provided greatest torque capacity for size and weight, no measurable backlash, extreme precision and long trouble-free life. Now! With newly designed Formchrome sprags, the best over-running clutches provide users with even higher performance.

Here's why! The new Formchrome sprags are made of hardened high carbon alloy steel with chromium diffused into the surface to form a chromium-carbide alloy. Thus, the sprag is corrosion resistant, and has high hardness and abrasion resistance similar to tungsten carbides. Result—sprag geometry is retained over a longer period and clutches can be used on higher over-running speeds. The Formchrome sprag is exclusive with Formsprag—no other clutch manufacturer can offer you its performance advantages.

Typical of the higher performance users can now receive from Formsprag clutches is this specific example: A Formsprag clutch using Formchrome sprags was installed in the reaction member of a torque converter and a competitive clutch in another. The competitive clutch showed excessive wear after the equivalent of one year of operation. The Formsprag clutch was run 50% longer and still showed only negligible wear.

There is a Formsprag clutch for every application—from business machines to aircraft. Standard clutches cover a wide range of uses and are described in the Formsprag Catalog . . . send for your free copy. However, to meet unusual requirements, Formsprag engineers will modify a standard clutch or design a special—send your application details.

Formsprag Clutches

FORMSPRAG COMPANY
23603 Hoover Road, Dept. 102
Warren (Detroit), Michigan

In Canada: Renold Chains Canada, Limited
In United Kingdom: Renold Chains, Limited
Distributors in Principal Cities

*Formchrome sprags are produced under a patented process. The use of this process in the manufacture of over-running clutches is exclusive with Formsprag.

FORMSPRAG CLUTCHES

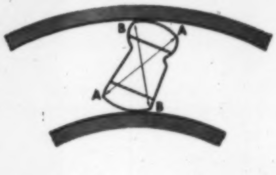
World's Largest Exclusive Manufacturer of Over-running Clutches

TYPICAL APPLICATIONS WHERE FORMCHROME SPRAGS HAVE PROVEN SUPERIOR PERFORMANCE

1. Used in operating submarine missile (Regulus II), Formsprag clutch allows alternator to over-run the hydraulic driving mechanism.
2. Backstop clutch on belt conveyor handling bauxite ore is subjected to higher over-running speed, extreme abrasive dust and hot weather—has been in operation a year.
3. Starter clutch for aircraft ground support system allows high-speed gas turbine to over-run starter unit.

For additional information on how Formchrome sprags assure better performing clutches, write for technical paper "Formchrome Sprags".

HERE'S

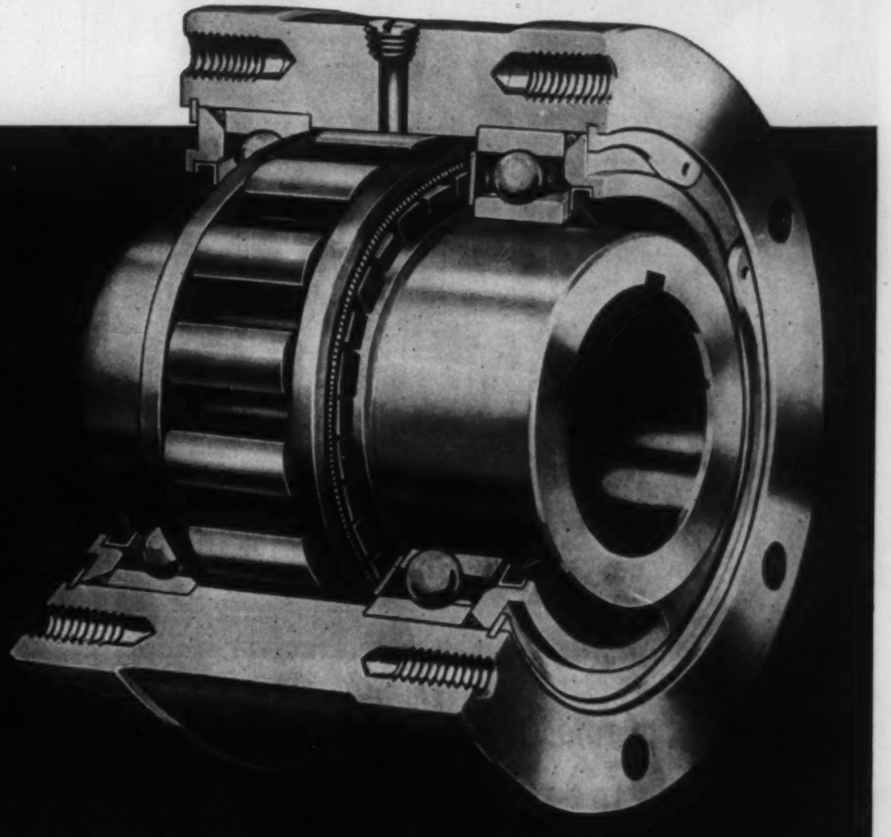


The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

FORMSPRAG OVER-RUNNING CLUTCHES WITH

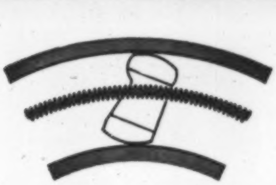
CHROMIUM-CARBIDE WEAR SURFACE
500 X

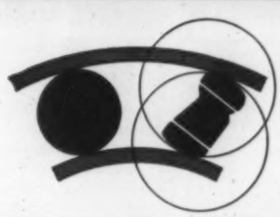
Micro-photo showing chromium-carbide wear surface (1900 Vickers—80 R_c) of Formchrome sprags. Chromium is diffused into high-carbon alloy steel sprag (62R_c).



OVER-RUNNING · INDEXING BACKSTOPPING

HOW IT WORKS

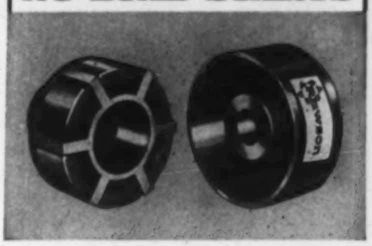




An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

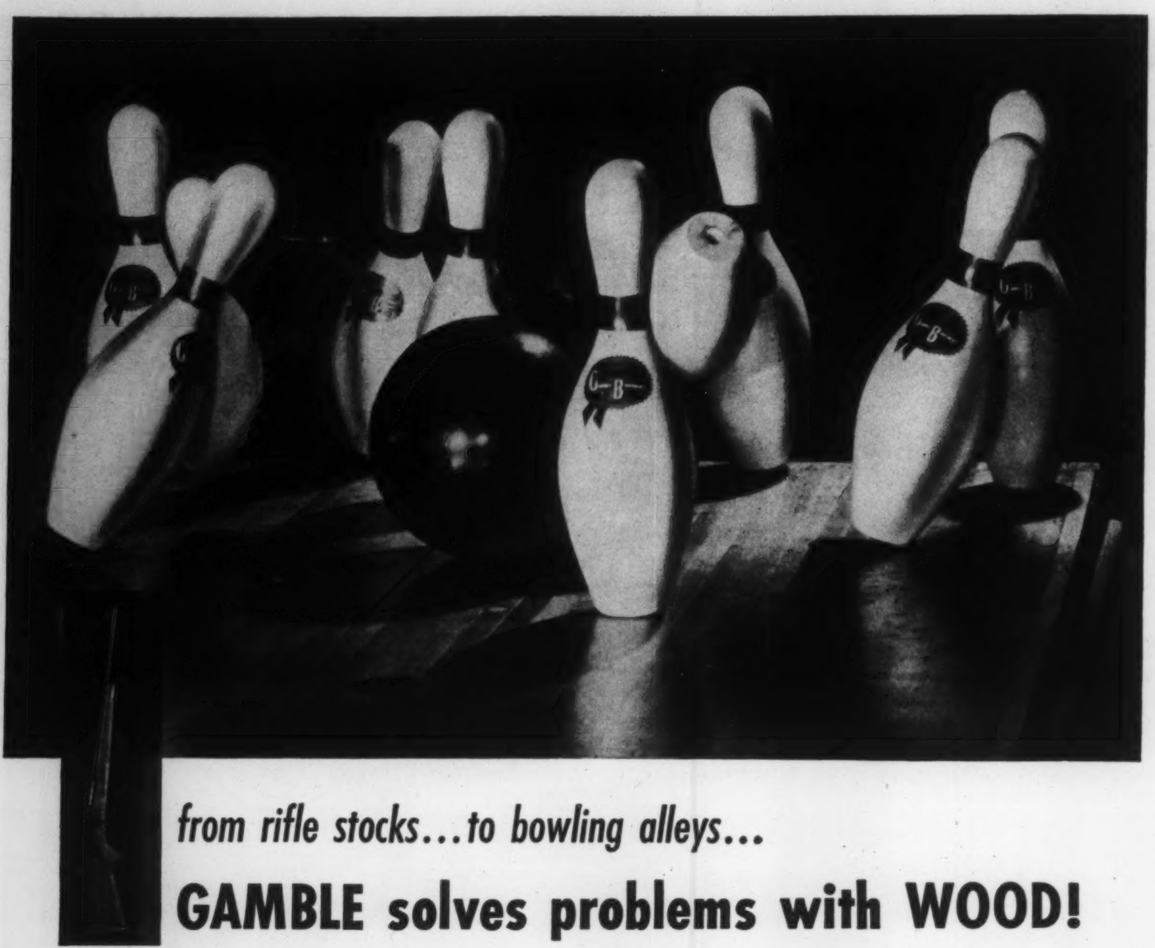
Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

RAWSON FOR NO·LOAD STARTS



Specify Rawson Automatic Centrifugal Clutches and Clutch Couplings. They protect the prime mover, eliminate need for costly reduced voltage starting equipment, permit use of less expensive smaller motors to start high inertia loads. Completely automatic and entirely mechanical in operation. Rawson clutches provide full overload protection, never need adjustment. Write for the new Rawson Clutch Catalog now.

Circle 461 on Page 19



from rifle stocks...to bowling alleys...

GAMBLE solves problems with WOOD!

Marksmen found that the slightest swelling or shrinking of their rifle stocks reduced firing accuracy. To solve the problem, a custom gunstock manufacturer turned to Gamble Brothers. Result: a laminated gunstock blank with greater dimensional stability, less tendency to warp, greater strength, and freedom from internal stresses.

To the pioneer producer of laminated pins — Gamble Brothers — came another problem from the bowling industry: need for ball return upsweeps and downsweeps on which the ball would not skid, then stop halfway back. Result: a laminated track which is stronger, takes less wood — and with proper friction factor for conveying ball back to bowler.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers — a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.

Solving Problems in Wood

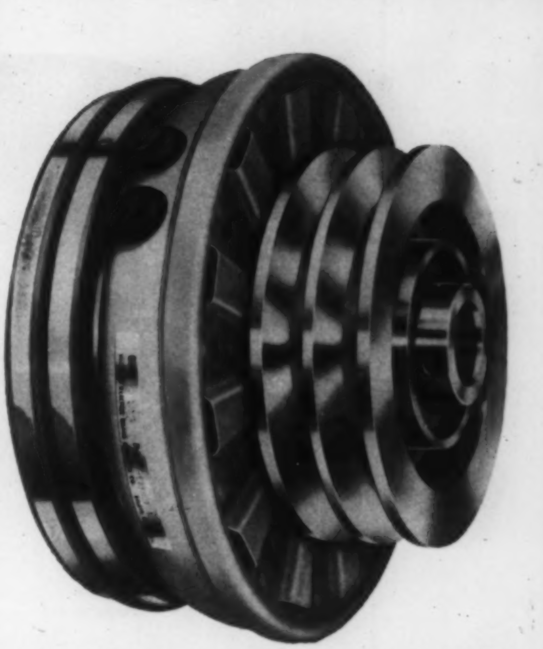
If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GUARANTEED BOND

GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

automatic control and easy jogging economical for any machine



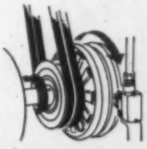
Warner's new Electro-Sheave

. . . adds all the benefits of electric motion control to any motor-driven machine at a practical price.

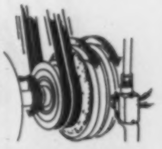
Warner's new combination clutch-pulley package saves you money two ways: 1) It comes to you off the shelf, in one, low-cost, precision assembly. You mount it directly to any standard NEMA motor shaft (new or old)—there is no engineering, machining, or alignment to worry about. Just slip it over the motor shaft, tighten a setscrew, mount the brushholder, belt the sheave to the machine and it's ready to go—in minutes. 2) It simplifies control. Any switch actuates the clutch. Simple wiring to the control panel and brushholder reduces assembly costs, eliminates mechanical linkages, levers, solenoids, and other actuating hardware.

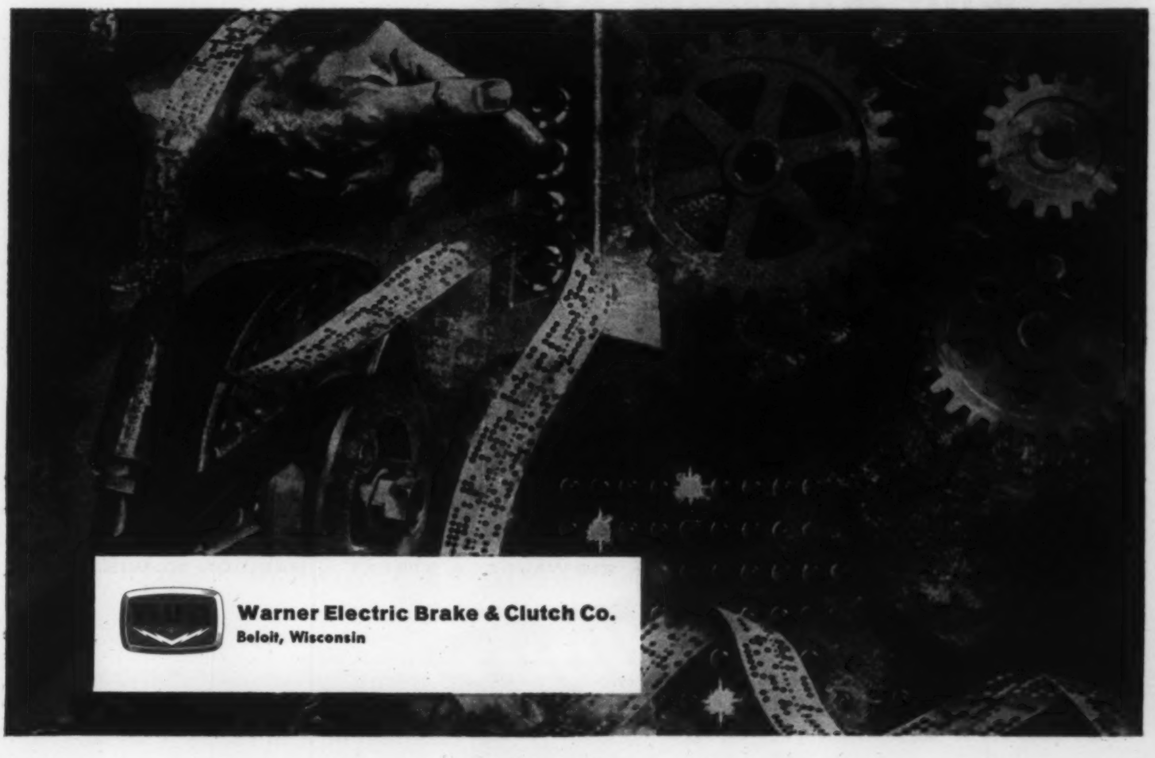
The Electro-Sheave fits right into your design scheme—gives your machines such advantages as faster no-load starting, precise inching and jogging, adjustable torque, automatic control, smaller drive motors, reduced power consumption, and longer motor life. Five sizes (1 to 25 hp) are now available from all Warner distributors. Sheave sizes and styles accommodate most power requirements.

For complete information on installation and operation, including cutaway drawings, description of controls, and selection charts—send for your copy of the new, fully illustrated 10-page booklet, No. P-52.

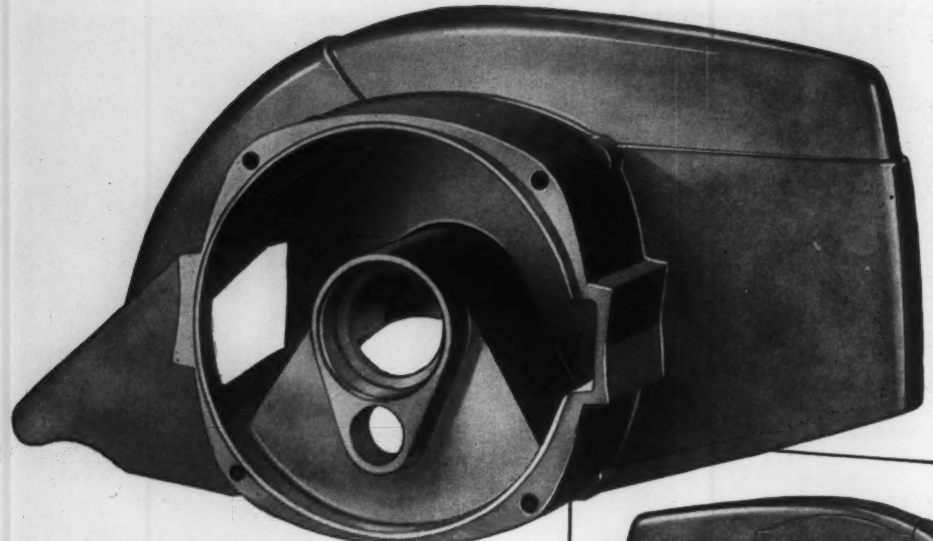


In operation . . . motor and shaft-mounted magnet run continuously. Sheave and armature are free-running on ball bearings. Energizing the clutch couples the rotating magnet and armature, transmitting motor torque to the drive sheave.





Warner Electric Brake & Clutch Co.
Beloit, Wisconsin



Upgrading...

with MADISON-KIPP zinc and aluminum die castings

Die casting as a process, has many inherent advantages in providing lightness, strength and stability in parts that can be cast to dimensions requiring a minimum of machining. These advantages have greatly assisted in upgrading many mass-produced products from automobiles to toys.

To get maximum process utilization, the seasoned and skilled mechanics at Madison-Kipp have proved very helpful to highly placed engineers and designers for over a quarter of a century.

Please clip this ad as a reminder to contact us when you have die casting requirements.

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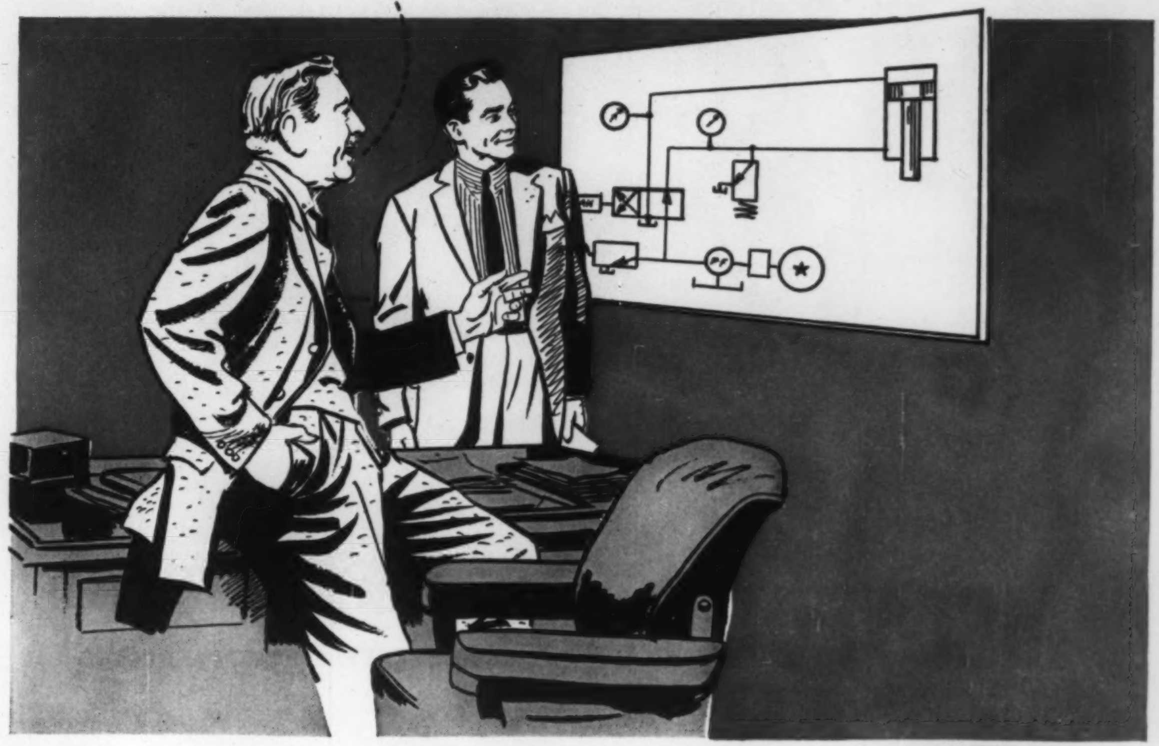
- Experienced in Lubrication Engineering
- Originators of Really High Speed Air Tools

"How do you know the packings will be compatible with that hydraulic fluid?"



There's only one fast, safe answer!

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THE ONLY
COMPLETE LINE OF
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FOR ANY
INDUSTRIAL HYDRAULIC
SYSTEM

Ask Houghton—the one manufacturer who designs, formulates and produces *all types of packings* and *all types of fluids*. Since Houghton can offer you any type of hydraulic packing in any material, the answer is completely unbiased.

"V" PACKINGS—a design plus! Houghton "V" packings of VIM leather and VIX-SYN homogeneous or fabricated rubber all have an identical stack height. This permits complete interchangeability, or mixing of "V's" within a set, without engineering changes.

"U" PACKINGS—available in all standard sizes. Cross-section meets JIC and AN Specifications. In VIM wax or rubber-impregnated leather . . . or VIX-SYN homogeneous synthetic rubber U-Cups.

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"O" RINGS—Houghton's large stock and fast delivery make it a preferred source for standard sizes. Specials on request.

For detailed information about Houghton's complete line of compatible hydraulic packings—or our full family of hydraulic fluids—call your Houghton Man today, or write E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Penna.

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Circle 465 on Page 19

MEL-TROL® gives you **design insurance** on forged high temperature parts

This turbine wheel forging will be machined down to $^1/_{16}$ in. thickness in some sections.

The better the forgeability, the easier and less costly the machining. But there can be no sacrifice of high temperature properties when you are depending on the strength of a minimum cross section, as this design does.

The only way to get both forgeability and uniform high temperature performance is to make sure of the uniformity and quality of the steel itself. To get a uniform forging, you have to start with a uniform billet. And a uniform billet can only come from a uniform ingot.

That's what MEL-TROL gives you.

Users of MEL-TROL high temperature alloys report they are the cleanest forging alloys of their type. Their performance in service is consistently good. It minimizes the variations in service life found in conventional alloys.

It's the result of the finest quality control tools and procedures known today used together with a new, *Carpenter*-patented mold which produces ingots with the highest uniformity yet achieved in commercial steelmaking.

And it's easy to get this new kind of "design insurance." Just call the nearest *Carpenter* Service-Center. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

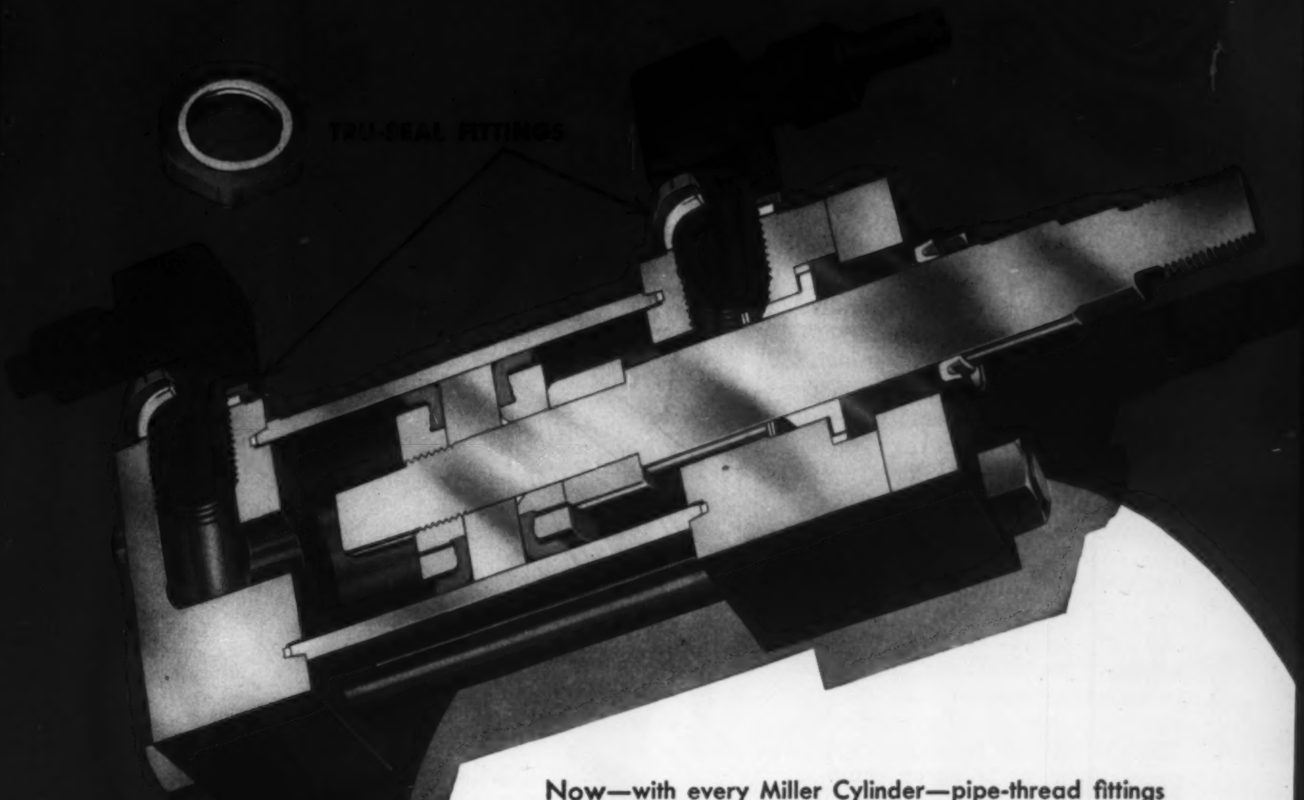
Carpenter STEEL

The Carpenter Steel Company
Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 466 on Page 19

NOW...even the PORTS have seals of the PRESSURE SEALING TYPE!

(J.I.C. Standard H6.2.1)



Now—with every Miller Cylinder—pipe-thread fittings (Tru-Seal) of the *pressure sealing type* are provided *at no extra cost* for sealing the cylinder ports.

Additional advantages of these fittings are:

1. All circuit piping and fittings can be easily positioned.
2. Damage to equipment caused by high tightening torque is completely eliminated (especially on valves, pumps, etc.)
3. Sealing material is Teflon, which is compatible with all hydraulic fluids (J. I. C. Standard H6.2.1)

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for Greater Reliability

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Engineering Bulletins
on Miller Air and Hydraulic Cylinders
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AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
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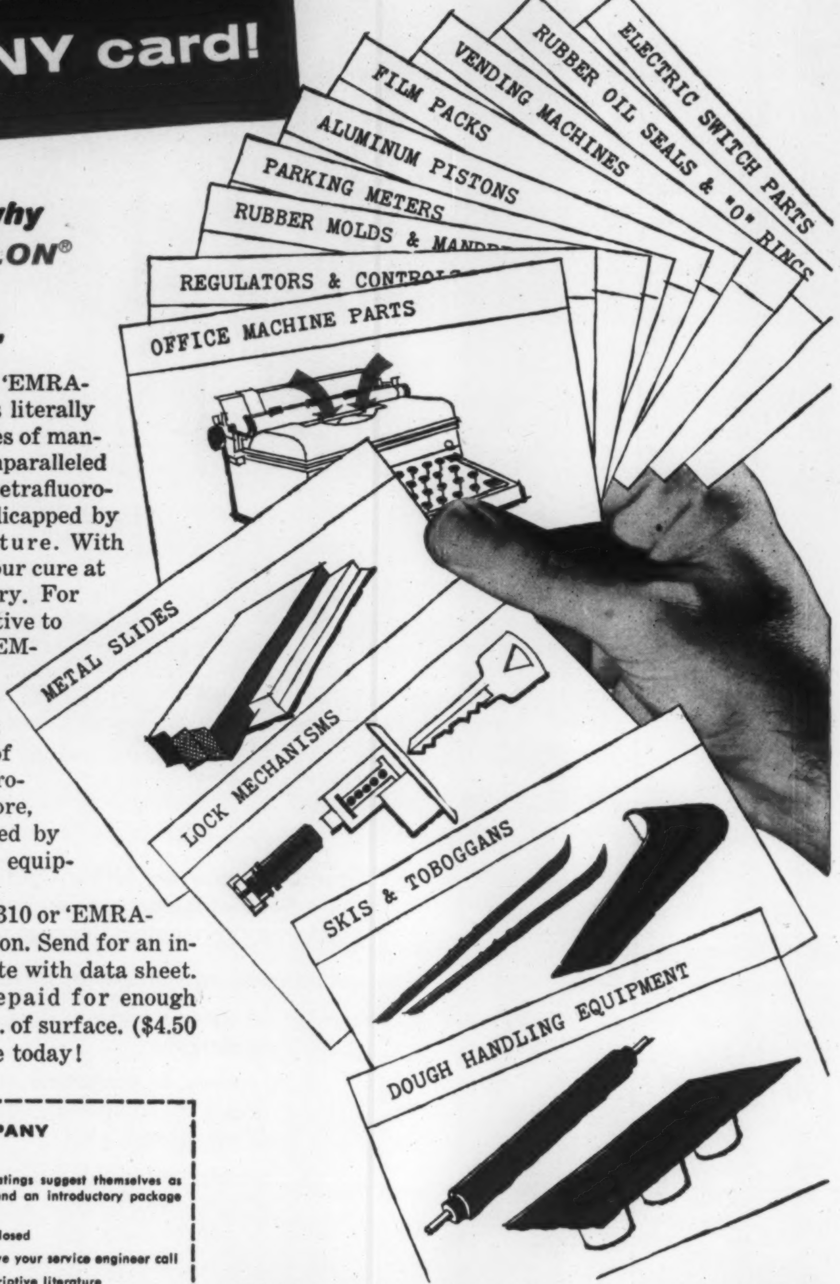
Circle 467 on Page 19

take a card ...ANY card!

...and you'll see why Acheson's EMRALON® is providing new application stories.

The recent introduction of 'EMRALON' surface coatings has literally "opened the door" for scores of manufacturers seeking the unparalleled properties of du Pont's tetrafluoroethylene (TFE) but handicapped by the high fusing temperature. With 'EMRALON' 310*, a one hour cure at 300°F. is all that is necessary. For substrates even more sensitive to heat, there is air drying 'EMRALON' 320†. In either case, these versatile new coatings provide excellent adhesion, low coefficient of friction, toughness and corrosion resistance. What's more, 'EMRALON' can be applied by conventional paint spray equipment.

Why not test 'EMRALON' 310 or 'EMRALON' 320 on your application. Send for an introductory package complete with data sheet. The cost is only $4.25 prepaid for enough material to coat 5,000 sq. in. of surface. ($4.50 west of the Rockies) Write today!


ELECTRIC SWITCH PARTS
RUBBER OIL SEALS & "O" RINGS
VENDING MACHINES
FILM PACKS
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RUBBER MOLDS & MANDR
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DOUGH HANDLING EQUIPMENT

ACHESON COLLOIDS COMPANY
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Gentlemen: Your new 'EMRALON' surface coatings suggest themselves as possibilities for a current design problem. Send an introductory package to me promptly.

☐ 'EMRALON' 310 (bake type) ☐ Check enclosed
☐ 'EMRALON' 320 (air-dry) ☐ Please have your service engineer call
☐ Bill me on Order No.________ ☐ Send descriptive literature

NAME: TITLE:
COMPANY:
ADDRESS:
CITY: STATE:
APPLICATION:

*'EMRALON' 310 is manufactured under exclusive license from E.I. du Pont de Nemours & Co. (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.
†'EMRALON' 320 — Patent applied for

ACHESON *Colloids Company*
PORT HURON, MICHIGAN
A division of Acheson Industries, Inc.
Also Acheson Industries (Europe) Ltd. and affiliates, London, England

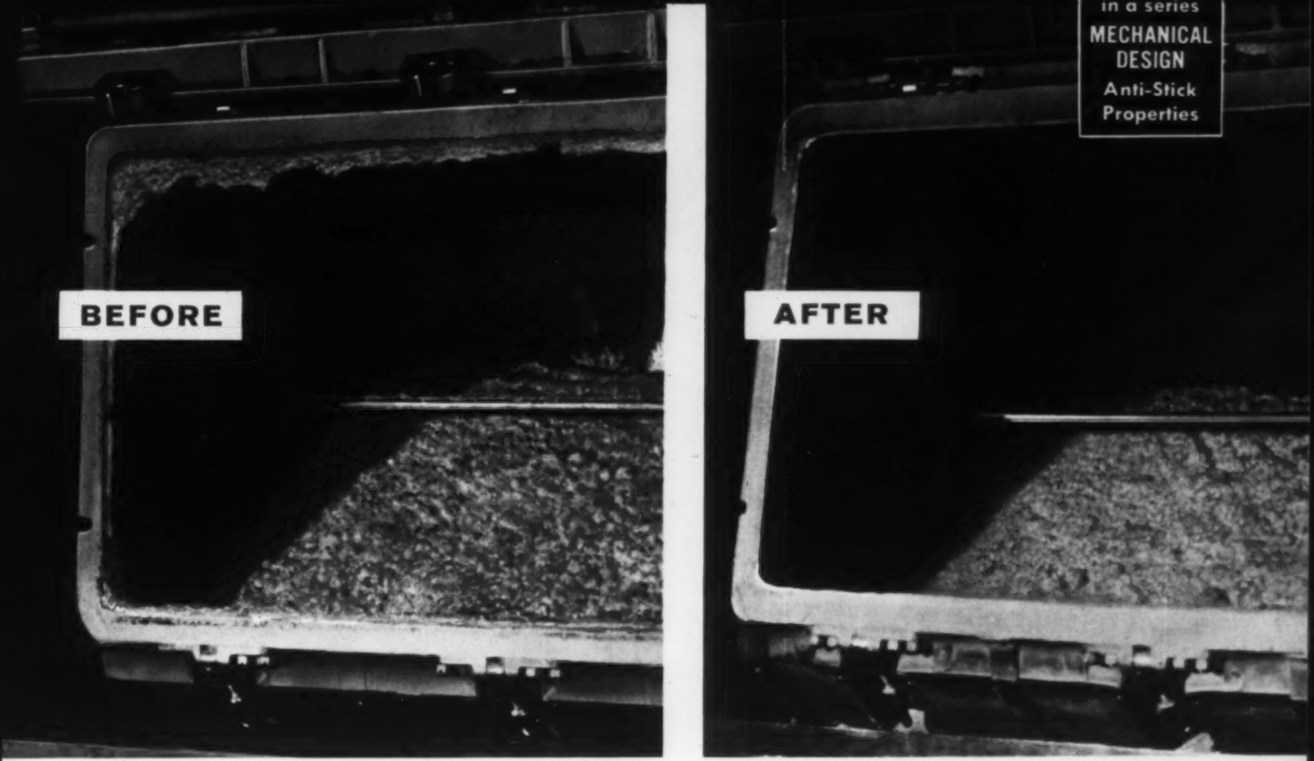
DU PONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS

Number 2
in a series
MECHANICAL DESIGN
Anti-Stick
Properties



MIXER handles a sticky intermediate in the manufacture of rayon. After every mixing operation 25 minutes were needed to scrape and clean mixer for the next batch. After surfacing with Du Pont TFE resins (right), the mixer could be dumped automatically and completely without scraping. Substantial labor savings and reduced downtime resulted in increased production.

Low adhesion of TFE resins creates new opportunities in product design and process engineering

Closely allied to the amazing low-friction properties of TFE resins are their equally remarkable anti-stick properties. Nothing sticks with any strength to the slick surface of these resins. On the molecular level, these properties are due to the very weak attraction of fluorocarbons for other molecules. Alert designers have found numerous ways to use the anti-adhesive properties of TEFLON TFE-fluorocarbon resins in both processing and products.

The general result is an improvement in operating efficiency and a reduction in costs. Where TFE resins have been used to modify an already running process, the savings have often been dramatic, as in the example above. Designers increasingly use TFE resins in original equipment. Anti-stick surfacing of TFE resins is available in the form of tape, sheet, film, tube and coatings.

On the following page you will see how the versatile properties of TFE resins in combination with their low adhesion help overcome a wide variety of design problems.

Some of the advantages gained by covering critical surfaces with TFE resins are:

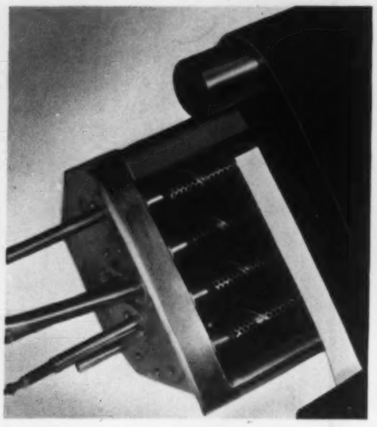
- Reduced cleaning time
- Reduced waste of materials
- Elimination of additives for reducing stickiness
- Elimination of mechanical devices for scraping
- No replacement of accessories used in handling adhesive materials
- Elimination of troublesome release problems in forming processes
- Improvement of heat transfer over that of equipment on which a thick, clinging film builds up
- Anti-icing

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

OVER

Resistance of TFE resins to sticking, heat, chemicals reduces maintenance . . . yields savings

DOUGH ROLLERS and conveyors coated with Du Pont TFE resins handle and knead sticky dough. Flour sprinkling is practically eliminated, material and maintenance cost reduced.



STRIP fastened to rounded edge of developer tank in white-printing machine stops adhesion of chemicals and sticking of paper. Strip and bearings of TFE resins are unaffected by NH_3.

5-MIL TAPE of TFE-fluorocarbon resin is used to line a vibrating trough. The liner prevents the sticking of salts, provides a constant feed and eliminates continuous maintenance.

Adhesion is frequently not the only problem in a design. Factors such as high temperature, corrosive materials, contamination of product and presence of moisture complicate the picture. But, because of the unique properties of TFE resins, a wide variety of adverse conditions can be overcome.

TFE resins are rated for continuous use to 500°F. They are among the most chemically inert substances known. TFE resins are tough and tear-resistant, have high flex strength, do not embrittle in extreme cold. They will not absorb moisture. In fact, they are water-repellent in addition to being anti-adhesive.

Thus, pipe liners of TFE resins successfully handle a very viscous, highly corrosive stream of high-boiling acids at 248°F. Heater jaws covered with TFE resins are used to heat-seal thermoplastic films. Film will not stick to the heater jaws when softened or melted. Hose liners of TFE resins make possible a new hot-paint spraying process. Hopper and vat coverings of TFE resins freely release bulk materials. Deposits from fumes do not adhere to hood and duct liners. Coated rollers stay clean. Chemicals remain uncontaminated.

The use of TFE resins results in cost-saving advantages. Since materials cannot cling to machine parts protected by the resins, machinery need not be stopped to remove accumulations. Clean-up time and maintenance are cut to a minimum with savings in labor and production costs. Waste of materials and equipment is reduced. The elimination of downtime sometimes permits an entire plant to operate on a faster and more regular schedule.

BONDING—Special techniques have been developed to permit bonding of TFE resins to other surfaces. Good bonding strength can be achieved between a treated surface of the resin and wood, glass, steel, aluminum, copper, ceramics, plastics—and, in fact, any material that will bond with an adhesive. Pressure-sensitive adhesives can be used, too. The coating of vats, troughs, rollers, conveyors, etc., with tape and sheet of TFE resins thus presents little difficulty. Information on bonding is available from Du Pont on request.

FORMS OF TFE RESINS FOR ANTI-STICK USE

SHEET OR FILM. Used where the surface is subjected to hard mechanical wear and may require periodic resurfacing. Where resiliency is needed. Where, because of size, type of base material, etc., it is not feasible to apply a finish.

ENAMELS OR FINISHES. Used where a thin film (1 to 3 mils) is desired over a metal substrate. Made from TFE resin dispersion, finishes can be used to coat extremely complex surfaces.

TUBING. Used unmodified or as a lining for pipe or hose to convey sticky fluids. Available in almost all desired diameters.

MOLDED PARTS. Used where a mechanically self-supporting component must be employed to solve an adhesion problem.

TYPICAL ANTI-STICK APPLICATIONS

PROCESS EQUIPMENT

- Heat-sealing equipment
- White-printing machines
- Dryer rollers
- Centrifugal pumps
- Dye vats
- Gluing machines
- Textile drying cans

AGRICULTURAL EQUIPMENT

- Plow facings
- Trough linings
- Conveyor chutes and belts
- Paint spray hose
- Feed hoppers and storage bins
- Funnels
- Fertilizer spreaders

FOOD INDUSTRY

- Bread baking pans
- Candy molds
- Cookie sheets
- Dough rollers
- Muffin pans
- Ice trays
- Candy conveyor belts
- Bread wrappers

MISC.

- Agitator paddles
- Barrettes
- Conveyors
- Snow-plow blades
- Paint pails
- Ladles
- Mandrels
- Paint mixers and drums

FOR MORE INFORMATION . . .

See your local supplier of TFE resins for information on the use of all forms of these resins in your anti-stick applications. Look for him under "Plastics—Du Pont" in the Yellow Pages. Supplementary engineering information on anti-stick and other properties will be sent to you on request. Write to: **E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Rm. T-25611, Du Pont Bldg., Wilmington 98, Delaware.**

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

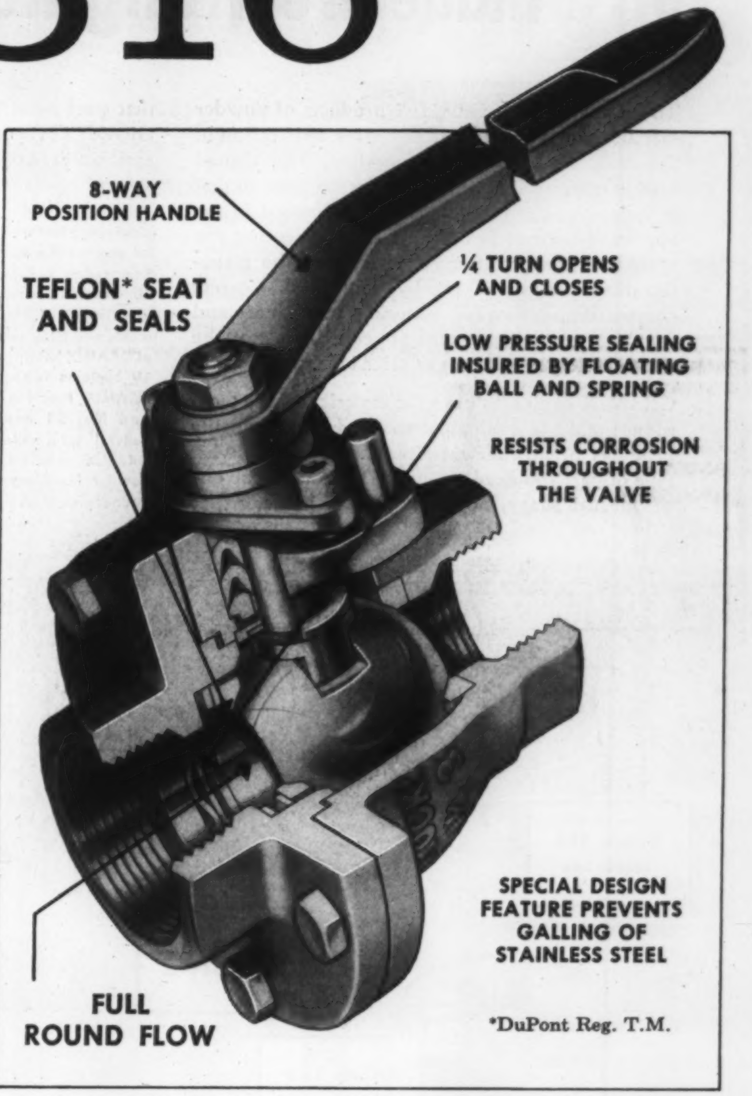
DU PONT
REG. U. S. PAT. OFF

TEFLON®
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Now you can get the famous advantages of ROCKWOOD Ball Valves—*IN STAINLESS STEEL*—

the "316"


8-WAY POSITION HANDLE
TEFLON* SEAT AND SEALS
¼ TURN OPENS AND CLOSES
LOW PRESSURE SEALING INSURED BY FLOATING BALL AND SPRING
RESISTS CORROSION THROUGHOUT THE VALVE
SPECIAL DESIGN FEATURE PREVENTS GALLING OF STAINLESS STEEL
FULL ROUND FLOW

*DuPont Reg. T.M.

Rockwood's new "316" Ball Valve gives you positive sealing over a wide range of pressures. A simple design utilizing a Teflon ball seat and spring assures you of low pressure sealing (spring behind ball forces ball against the seat) and high pressure sealing (pressure supplements spring for pressure-tight seal). Friction loss and turbulence are also greatly reduced because of the "316's" straight full round flow passage. Features like these have made Rockwood the most dependable name in Ball Valves.

The new Rockwood "316" comes with various types of seats, remote air-operation of wanted sizes, ⅜″ through 2″ screwed ends, 3″, 4″, 6″ and 8″ flanged ends. 600 W.O.G. minus 100°F to 400°F. And it's just one of a complete line of Rockwood Valves and Unions.

Write for Rockwood's new catalog — the inside story of Rockwood Ball Valves is worth knowing. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD SPRINKLER COMPANY
800 Harlow Street, Worcester 5, Massachusetts

Send me your new Rockwood Full-Flow Ball Valves Catalog No. 57.

Name.................................*Title*..................

Company..

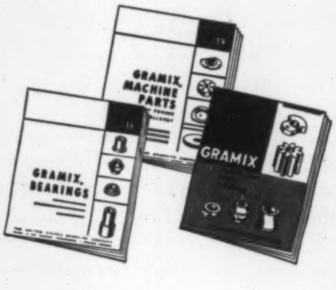
City.............................*Zone*....*State*..............

GRAMIX® products made from engineered alloys

To be positive that GRAMIX products of powder metallurgy will function in any given application in the most efficient manner possible, The United States Graphite Company *engineers* the alloy so that it meets exact physical properties required in the application. And, in addition to engineering the alloy to the application, every step in the manufacturing process is rigidly controlled. Correct compacting, controlled sintering procedures and precise finishing operations contribute to the dependable performance of GRAMIX parts.

GRAMIX engineers have the experience, the techniques and the equipment to produce top quality products of powder metallurgy. No matter what type of part you need . . . gear, cam, ratchet or one of unusual shape, no matter what characteristics that part must possess, it will pay you to select GRAMIX . . . and get both "job-engineered" alloys and quality-controlled production to meet each specific operating requirement.

Write today for these helpful engineering manuals. Engineering Bulletin No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 contains facts about GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy. Get your copies now.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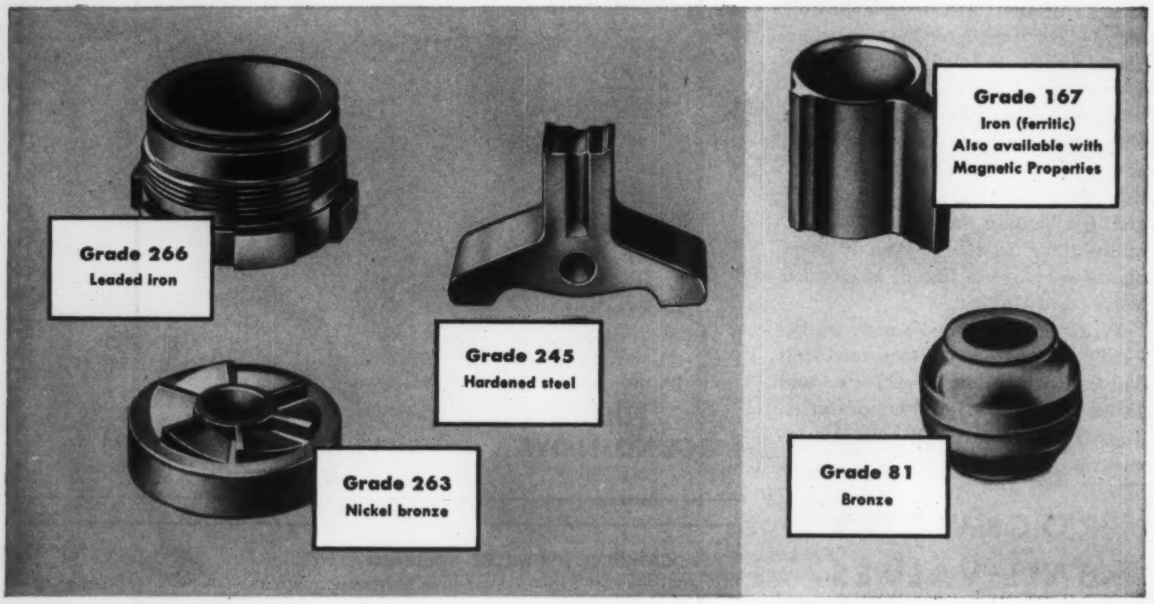
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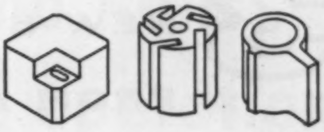

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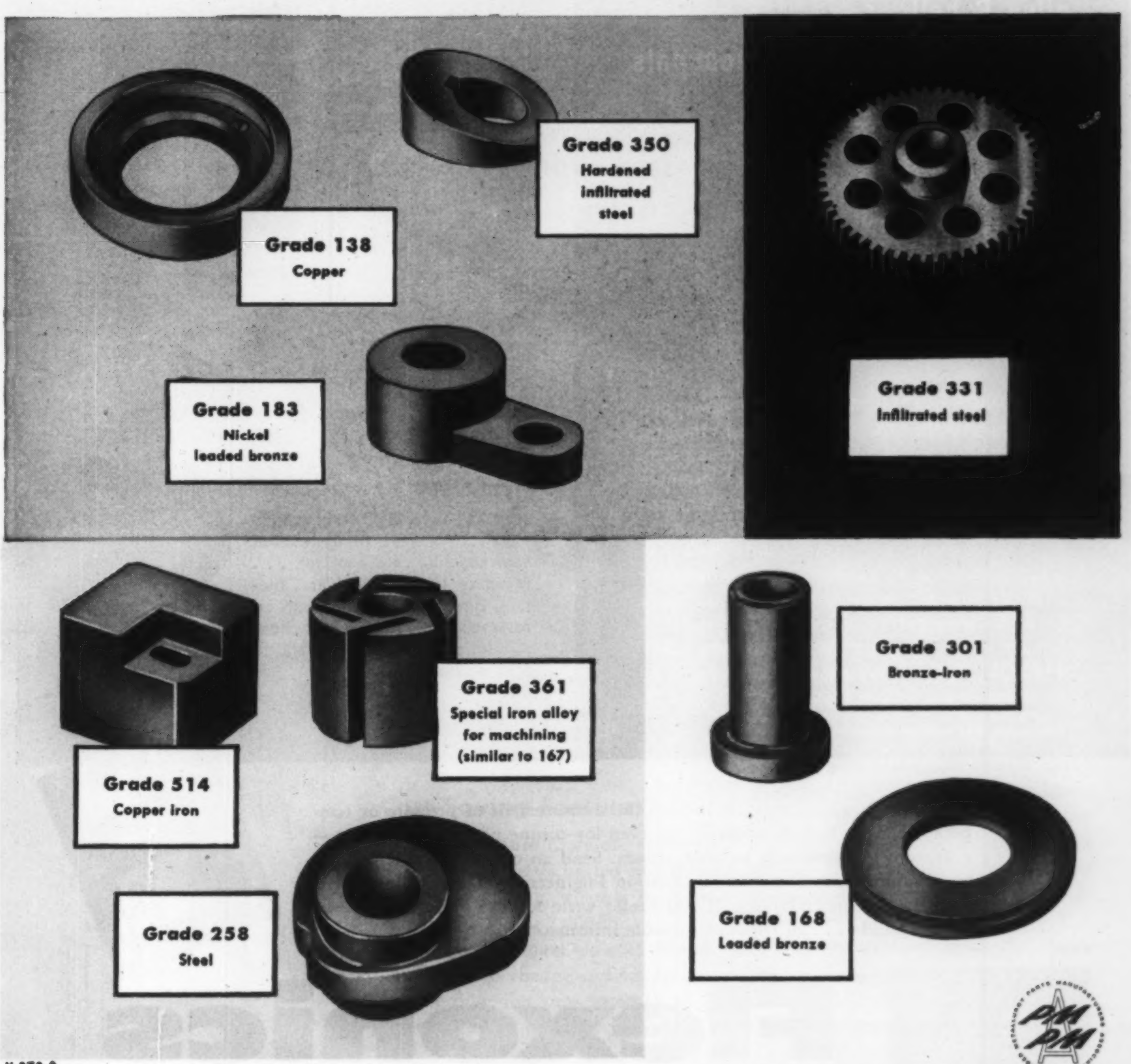
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Special iron alloy for machining (similar to 167)
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Grade 258
Steel
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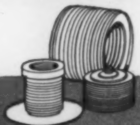
Circle 471 on Page 19

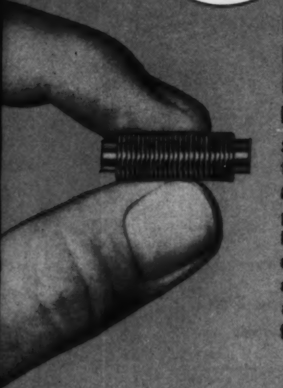
3 NEW BELLOWS DEVELOPMENTS FROM Flexonics

new FLEXONICS Hastelloy* alloy B bellows — to strong chemicals

FLEXONICS new Hastelloy alloy B bellows open new opportunities to the designer for efficient, dependable control of flow and pressure of certain highly corrosive media. For example Hastelloy alloy B is well suited to handle hydrochloric acid at all concentrations and temperatures, including the boiling points, and has good resistance to sulphuric and phosphoric acid, hydrogen chloride gas, as well as many other severely corrosive media. The metal is similar in strength and ductility to alloy steel. FLEXONICS Hastelloy alloy B bellows can be supplied in sizes from 13/32" I.D. to 5-3/4 I.D.

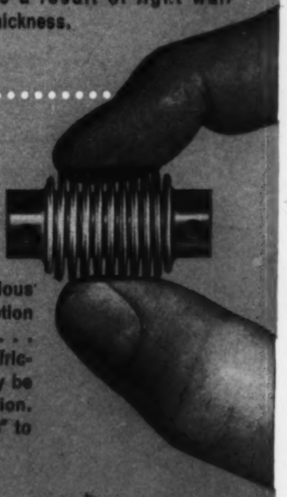
*Registered trade mark Union Carbide Corporation





new miniaturized FLEXONICS bellows... nominal 5/32" I.D.

Seamless, hydraulically formed precision bellows in a wide range of metals and performance characteristics. Exceptional strength . . . and extreme sensitivity to temperature and pressure changes as a result of light wall thickness.



new FLEXONICS miniaturized flexible couplings from stock

As small as 15/32" O.D. in various metals. Transmit rotary motion with absolute zero backlash . . . minimize bearing wear and friction. Direction of rotation may be reversed without loss of action. Accommodate shaft sizes 1/8" to 5/16" diameter.

FLEXON BELLOWS

For design applications that involve the measurement of pressure or temperature . . . a flexible sealer . . . or even low-torque power transmission — a Flexonics Bellows can be your answer. Send an outline of your bellows applications — the Flexonics Application Engineering Staff will be pleased to make recommendations. If you prefer write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.

B-505

TOMORROW'S
ENGINEERING
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BELLOWS

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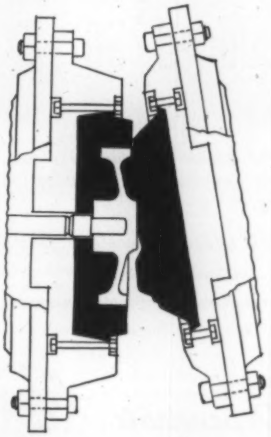
Unique Mill Forges and Rolls circular products in one operation

In less than one minute, this Bethlehem mill—the only one of its kind in the country —turns out a top-quality impression-die steel forging at a cost that's hard to match.

This is Bethlehem's famed circular-products mill—the Slick Mill. Named for its designer, Edwin E. Slick, this unique machine produces impression-die circular forgings ranging from 10 in. to 46 in. OD; as-rolled weights ranging from 100 to 2,000 lb. It handles almost any grade of steel—carbon, alloy or stainless, as well as certain heat-resistant grades.

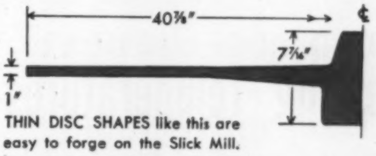


How It Works

Designed to operate in a horizontal plane, Bethlehem's Slick Mill is constructed with two *revolvable* spindles on which face plates are mounted. These face plates support the impression dies that form the steel billet into shape by a combination press and rolling action.

After the steel billet is heated and descaled, it is centered between the dies of the Slick Mill. Then a 1500-ton hydraulic ram actuates the spindle on the straight side of the mill, upset forging the billet. When this cycle is completed, a 2,000-hp motor actuates the spindle on the angle side of the mill and the rolling cycle begins. By continuing the upsetting action and rotation of the dies and work, the material flows into the recesses of the dies, resulting in the desired shape. *The entire rolling cycle takes about one minute.*

After rolling, excess material in the form of flash is sheared off; the hub, when necessary, is punched; and the forging is inspected.



THIN DISC SHAPES like this are easy to forge on the Slick Mill.

Cost-Saving Features

Quick operation: Only one minute is needed to convert a heated slug into a contoured forging, whether the product weighs 100 or 2,000 lb.

Quick die changes: Only 15 minutes are needed to change and set up dies. Even production runs as small as 25 or 50 pieces are economical.

Low die charges: Since contact time between die and work is very brief, and because there is no impacting, low-cost die blocks can be used. In many cases, die charges are ⅓ to ½ less than conventional impression dies.

Less steel needed: Utilizing the principle of forging design, the Slick Mill can produce lighter-weight sections without sacrificing strength.

Good physical characteristics: The process insures excellent grain flow, machinability and soundness.

Bethlehem's Slick Mill is readily adapted to jobbing or production quantities of forged circular products such as: gear blanks, fly wheels; crane track wheels; sheave wheels; brake drums; clutch discs; couplings; tire moulds; and turbine or compressor wheels. Products may be specified as-rolled or rough machined to specifications.

Your inquiry—whatever the quantity involved—will receive prompt attention. Call or write the Bethlehem sales office nearest you today.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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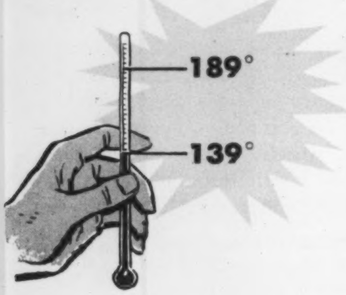
THE MAGIC OF *Norgren* MICRO-FOG LUBRICATION



Bearing Temperatures Reduced 50° F*

Automatic, centralized Micro-Fog Lubrication was installed early in 1957 by Gould Paper Co., Lyons Falls, N. Y., on the dryer section of this paper machine. It has lowered the average operating temperature of all 86 half bearings (9½" dia. x 12") from 189° F to 139° F. Two other similar machines were also converted by this company to Micro-Fog — a total of 368 bearings of all types.

The magic of Norgren Micro-Fog *provides these additional benefits at Gould:*

1. Elimination of frequent bearing failures.
2. Elimination of the cost of hand oiling and block grease replacement.
3. Elimination of fire hazard from dripping lubricant.
4. No product contamination.
5. 66% reduction of lubricant consumption.
6. Perfect lubrication for all bearings.

If it's Norgren... It's Dependable.

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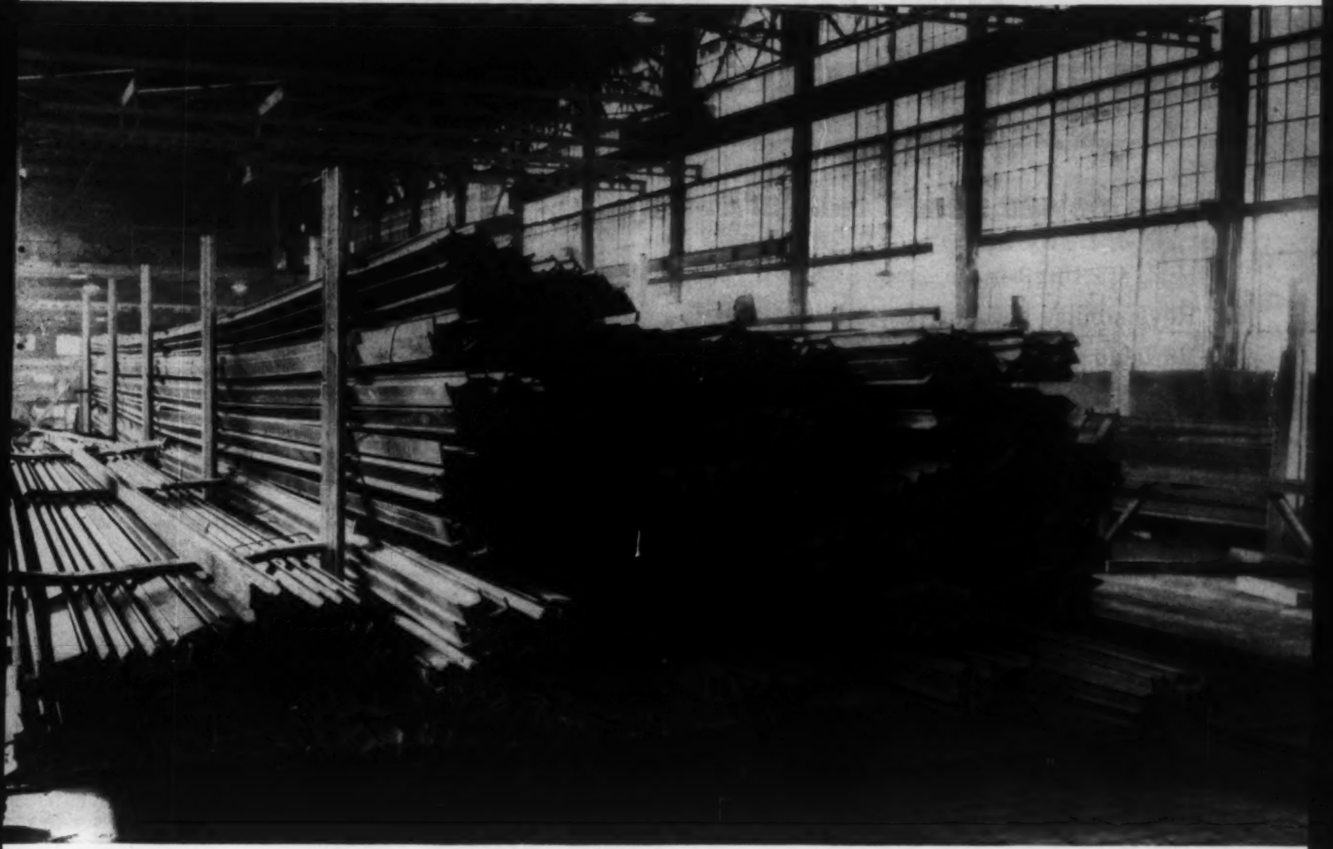
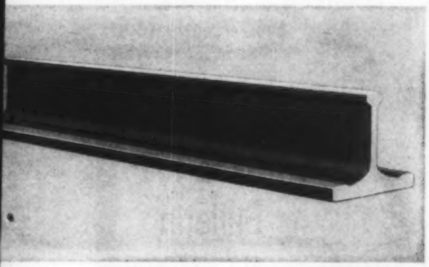


Tramrail—non-peening, no machining made from USS Special Sections



A one-piece rail rolled for the runway of Cleveland Tramrail Systems. This track has flat raised treads designed to minimize peening. No machining is required on this USS Special Section.

This supply of rails for Cleveland Tramrail Systems represents a cost saving running into many thousands of dollars. They are USS Special Sections rolled to exact size and cut to proper length. If the rails had to be machined from bars of high-carbon or alloy steel, the cost would be prohibitive and scrap losses tremendous.

The steel is furnished in a high carbon grade which serves to minimize track wear caused by wheel peening on the track tread. The manufacturer says that in 30 years no other overhead track has been offered that surpasses this one for durability.

It's seldom that better products can be produced at substantially lower costs but that's what happens when you use rolled USS Special Sections. Rolled to the predominating cross section needed, it is a custom-tailored part, designed and rolled so that there is little or no finishing required to meet final specifications.

Why not find out what USS Special Sections can do for you? This is one *sure* way you can help to keep costs down and get faster production at the same time.

Write for our new book, USS Special Sections. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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United States Steel Corporation—Pittsburgh
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Tennessee Coal & Iron—Fairfield, Alabama
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- Variable speed, easily controlled
- Cool operation
- Instantaneous starts and stops
- Consistent torque output
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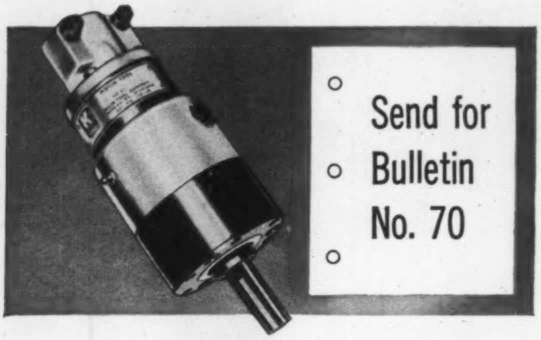
- Thrust or axial spindle loads
- Enclosed construction
- Output from 1/8 to 16 hp

Air motors are the answer

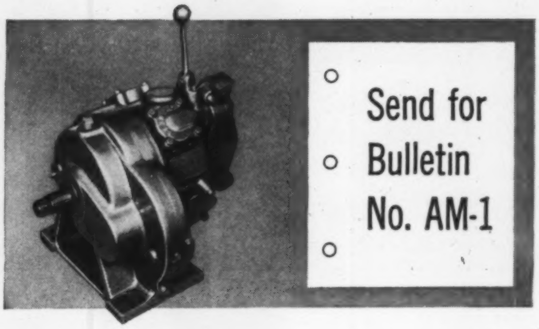
Call your Gardner-Denver air tool specialist soon or write for bulletins.

AT HOME A LONG WAY FROM HOME

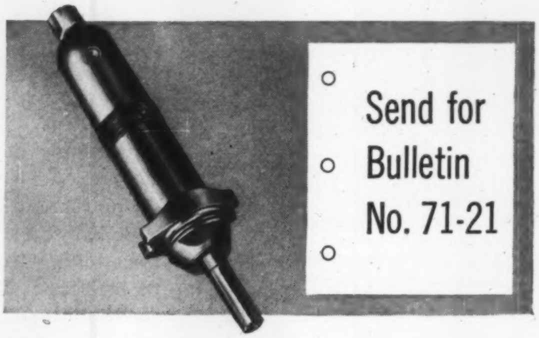
Factory-trained specialists in Gardner-Denver plants and offices throughout the world have parts and facilities to keep our products on the go—wherever they go. At Gardner-Denver *there's no substitute for men*—our 100-year philosophy of growth.



Axial Piston Air Motors, 0.6 to 2.7 hp



Five-Cylinder Radial Air Motors, 3 to 16 hp



Rotary Vane Air Motors to 1.6 hp

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Circle 475 on Page 19

Technical data for gasket design and selection

Why close tolerances in resilient gaskets are rarely necessary

Tolerances in the size and shape of a gasket do not become critical if the gasket material chosen seals effectively over a wide compression range.

Armstrong cork-and-rubber compounds are typical of such wide range materials. They seal under compressions from 20% to 33%.

Because they are truly compressible, they decrease in volume under load, so tolerances in size may be as wide as .010", even in completely confined space. In some applications, the wider tolerances allowed by compressible gaskets may effect savings in machining time.

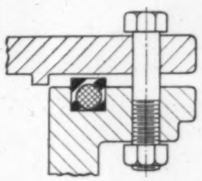

FIG. 1

The typical examples shown here illustrate how Armstrong cork-and-rubber materials help eliminate the need for close tolerances.

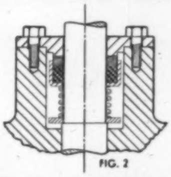

FIG. 2

Figure 1 shows relative sizes of a resilient cork-and-rubber gasket and a non-compressible molded ring of comparable size. The cork-and-rubber compound permits wide tolerance in its size, whereas the molded ring must meet very close tolerances to allow perfect fit between the flanges.

Similarly, in figure 2, wide tolerance cork-and-rubber gaskets make an effective packing ring. Their true compressibility controls lateral flow and prevents excessive build-up of radial pressure on the shaft.

Selecting gaskets for sealing internal pressures under stamped flanges

Effective sealing of stamped flanges is complicated by their normal surface irregularities and by a tendency for these light flanges to distort under low bolt pressure. Where these lightweight components must also seal internal pressure, the gasket problem usually will require special attention.

A pump manufacturer recently submitted such a problem to the Armstrong Research and Development Center. One flange of his pump was stamped sheet metal, with a nominal .125" thickness. A soft fiber gasket—approximately .090" thick—was used to seal water at 200° F. The pumps leaked under internal service pressure of 70 psi.

In the Deflectometer, fluid under pressure is pumped into the flange. The amount of deflection can be read from a micrometer which is held in fixed position relative to the flange surface. By moving the arm, readings can be taken at any point on the flange surface.

To find exactly how the internal pressure was causing leaks, research engineers used the Deflectometer, an Armstrong-developed laboratory tool. (See photo)

In the pump flange, under test, deflections of .007" at the center points between the bolts were found. (At flange center, the deflection was .040".)

The engineers then turned their attention to the gasket material, a relatively soft, compressible fiber sheet. Such a material requires fairly high bolt pressure to close its interstices, and such pressures were not available on the stamped flange. The deflection caused by the internal pressure was enough to open the gasket structure and permit leakage.

To find a gasket material that would provide an economical seal under the conditions imposed by the pump, the engineers tested various Armstrong materials. From among the several that sealed satisfactorily, they recommended Accopac N-840, a dense, beater-saturated fiber material.

N-840 offered several advantages. For example, none of the available bolt pressure was required to compress it to impermeability. And it could be used in 1/32" gauge—one-third the thickness of the original gasket.

More complete information on the effect of internal pressure and other factors of gasket design, selection, and performance is contained in the Armstrong Gasket Design Manual. Write for your copy to the address below.

For your copy of the Armstrong Gasket Design Manual, write to Armstrong Cork Company, Industrial Division, 7006 Dean Street, Lancaster, Pa.

GASKET
DESIGN
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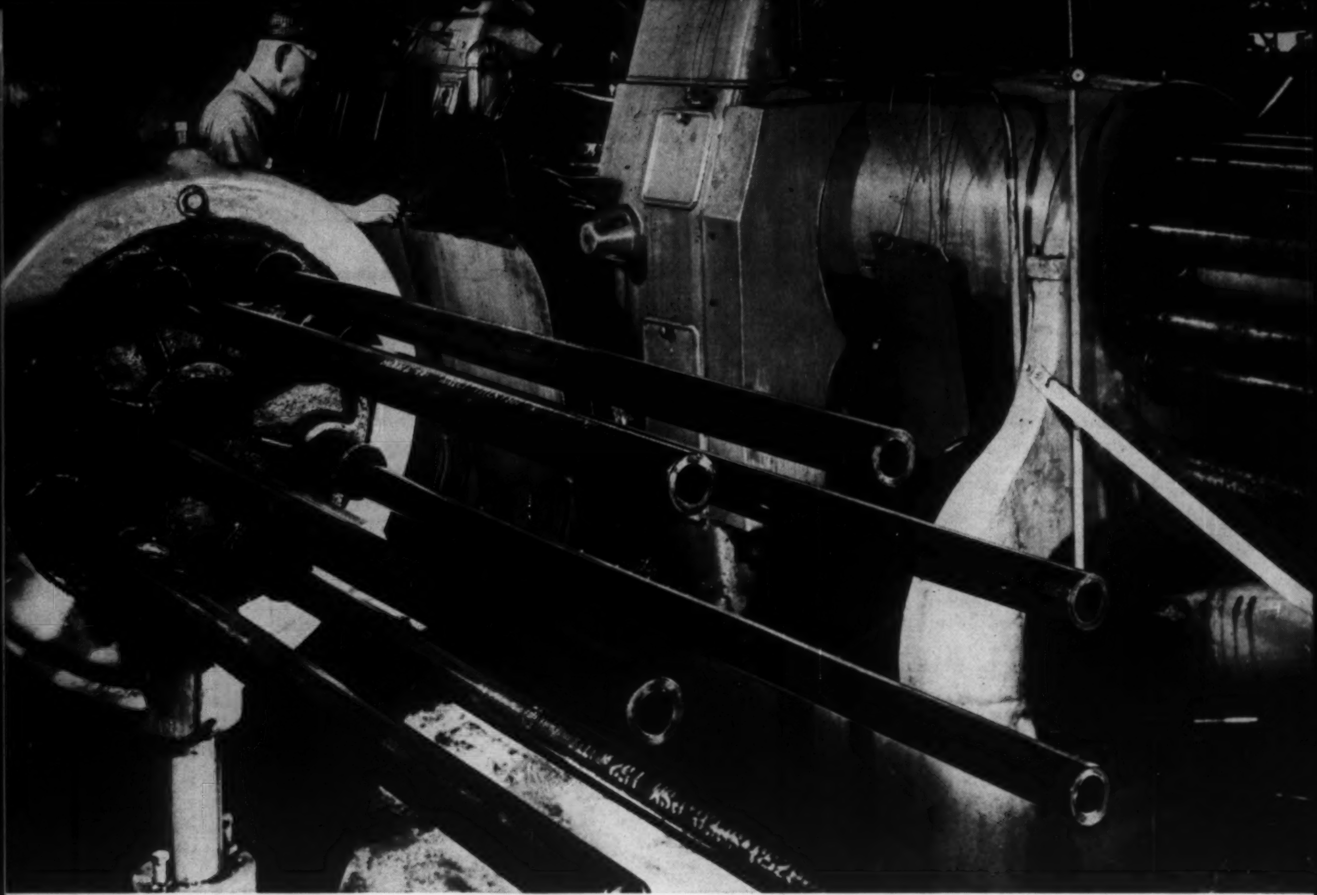
Armstrong GASKET MATERIALS

. . . used wherever performance counts



Bearings in the making are these lengths of Pittsburgh seamless mechanical tubing in the charging rack of a high-speed automatic cutting machine at the plant of a leading bearing manufacturer. Special machining, hardening properties are built into tubes for this customer who produces more than 6,000 inner-rings per day.

Leading Bearing Maker Finds . . .

Machinability of Pittsburgh Steel's Tubes Lengthens Tool Life, Gives More Pieces

One of the nation's oldest and largest ball bearing makers used alloy bars for high-speed machining of a difficult bearing part for 20 years.

But when Pittsburgh Steel Company showed how low-carbon steel tubes could provide the machining and case-hardening properties required, this big-name manufacturer switched to Pittsburgh seamless mechanical tubing.

These were the clinchers:

- **More pieces per day**
- **Longer tool life**
- **Less machining and scrap**
- **Lower cost material**

The part involved was the inner-ring of a clutch throw-out bearing—a heavy production item at this customer's biggest plant since 1937. The bearing is the part that takes the abuse from the spinning clutch pressure-plate when you step on the clutch pedal.

To produce the inner-ring from low carbon steel, the customer demanded seamless tubing that was:

Highly machinable and uniform—for charging into a battery of 8-spindle automatic screw machines which subject each piece to 16 cutting operations.

Exceptionally hardenable and fine grained—for heat-treating to the hardness demanded of bearing steel and for finishing to ultra-close tolerance and super-fine surface.

The customer specified the grade of steel he needed to obtain these properties—AISI C-1024—then asked Pittsburgh Steel's sales engineers to produce it in seamless mechanical tubing.

The bearing maker's automatic machines produce 6,000 to 6,500 bearing inner-rings a day, testing the tubing's machinability with cutting tolerances as little as .003 inch.

Its hardening properties are

proven in a 21½-hour carburizing-hardening-temper cycle.

Structural characteristics meet the test in an integrated finishing-assembly operation that includes grinding and honing, and two 100 percent test operations.

The bearing maker's superintendent of primary operations sums up the advantages of Pittsburgh Steel's mechanical tubing this way:

"We get more pieces during a day's operation. And we don't have as many chips to pull.

"We can use a boring tool and this stays in service longer than the drill needed for bar stock. Other tools used for ID cuts also stay in longer. So there we have lower tool costs.

"Finally, we are using a less expensive steel and gaining cycle speed. Since the inside drill speed is the controlling factor on cycle speed for bar stock, the elimination of this operation and the substitution of a boring tool permits cycle speeds of 25 seconds for tubing compared with 28 seconds for alloy bar stock or a little over 10 percent reduction."

This customer's experience with Pittsburgh Steel's seamless tubing—the advantages, the quality, the results—is typical of Pittsburgh Steel's ability to supply tubular products for special applications and of its ability to help customers obtain more profitable production.

These same benefits can be tailored to the needs of your operation requiring seamless mechanical tubing or any of the other tubular products made by the skilled tubemakers at Pittsburgh Steel Company.

Initial assembly—one of two 100 percent testing operations—is where seamless shows its merits in finished bearing.

Tubing proves its machinability here where it takes 16 boring, reaming, grooving, recessing and burnishing cuts.

Pittsburgh Seamless Distributors

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Chicago Tube & Iron Company
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Cleveland Tool & Supply Co.
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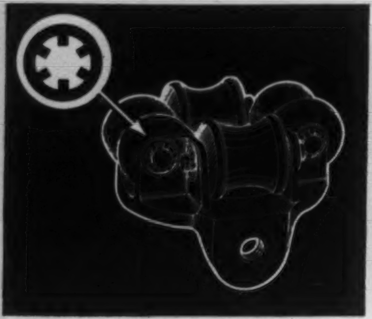
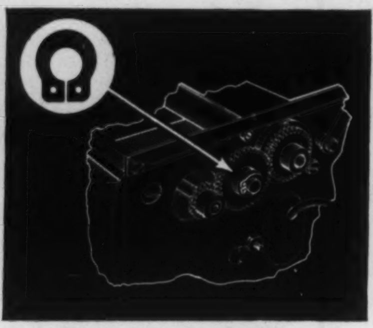
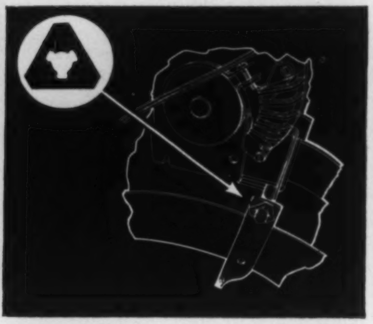


Drilling and flaring eliminated. Easier maintenance, a time saving of 50% and elimination of costly, time consuming drilling and flaring operations result when Truarc Series 5115 self-locking rings are used to retain rollers on pins in this electric cable guide. Extra long prongs enable ring to accommodate wide shaft tolerances.

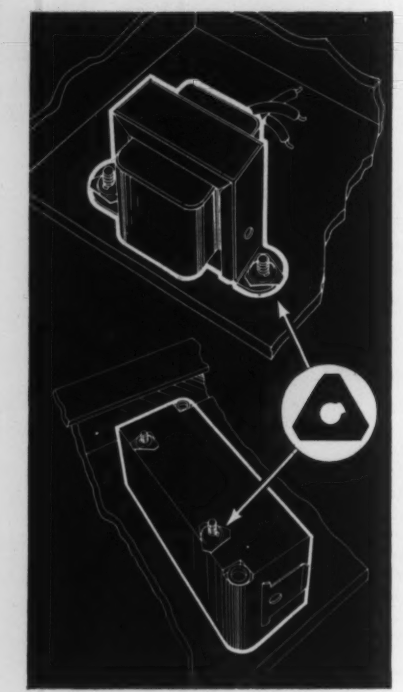


Economical fastening for idler gear. Installing Truarc Series 5555 Grip Ring flush with hub insures precise seating of gear in this portable electrocardiograph assembly. What's more, the ring eliminates a nut and costly stud-threading operation of alternate design. **Typical savings amount to $365 per 1000 units.**



Cross-drilling and cotter pin eliminated. Here a Truarc Series 5305 self-locking triangular retainer replaces a cotter pin used to hold an electric-motor mounting bar. Both the cotter pin and the cross-drilling operation required in the original design are eliminated. **Typical total savings amount to $120 per 1000 units.**

Truarc self-locking retaining rings boost economy in wide variety of designs



Easy way to mount electrical-electronic parts. Truarc Series 5300 triangular nuts replace conventional nuts and lockwashers in mounting electrical parts like transformer (top) or Microswitch (bottom). Dished body of Series 5300 flattens under torque, eliminates need for lockwasher, simplifies handling and assures assembly.

...eliminate parts, machining, speed assembly

Easy application, elimination of more expensive conventional fasteners and reduction or elimination of machining operations are just a few of the savings resulting from the proper use of self-locking retaining rings. Rings replace threaded retainers and nuts, hairpin-type cotter pins, and a variety of cut, lock, and plain washers. They require no groove, or preparatory machining operations. Rings can be installed by unskilled labor, seated at any point on the shaft, automatically taking up any accumulated tolerances.

Four ring types are shown. One has a dished triangular body which locks the fastener on the shaft under spring tension, holds under moderate shaft tolerances and against extremely heavy thrust loads. Another, a re-usable Grip Ring, is ideal for ungrooved shafts, tubes, bosses, and studs. A third type is a triangular free-spinning nut with a dished body that flattens under torque, eliminating need for separate lock washers. The fourth, a push-on type, has an arched rim to provide high strength and extra long locking prongs which accommodate wide shaft tolerances.

These are but four of the 50 functionally different types of Truarc retaining rings. They come in 740 standard sizes, 6 metal specifications, 13 different finishes. The entire Truarc line, including assembly tools, grooving tools, and 80 typical cost-saving applications, is covered in the new catalog RR 10-58. And remember, Waldes engineers are always ready to help you solve your application problems—whether they involve one of the standard Truarc rings or a "special" to fit your particular requirements. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

9.15

WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor, Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS . . . THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

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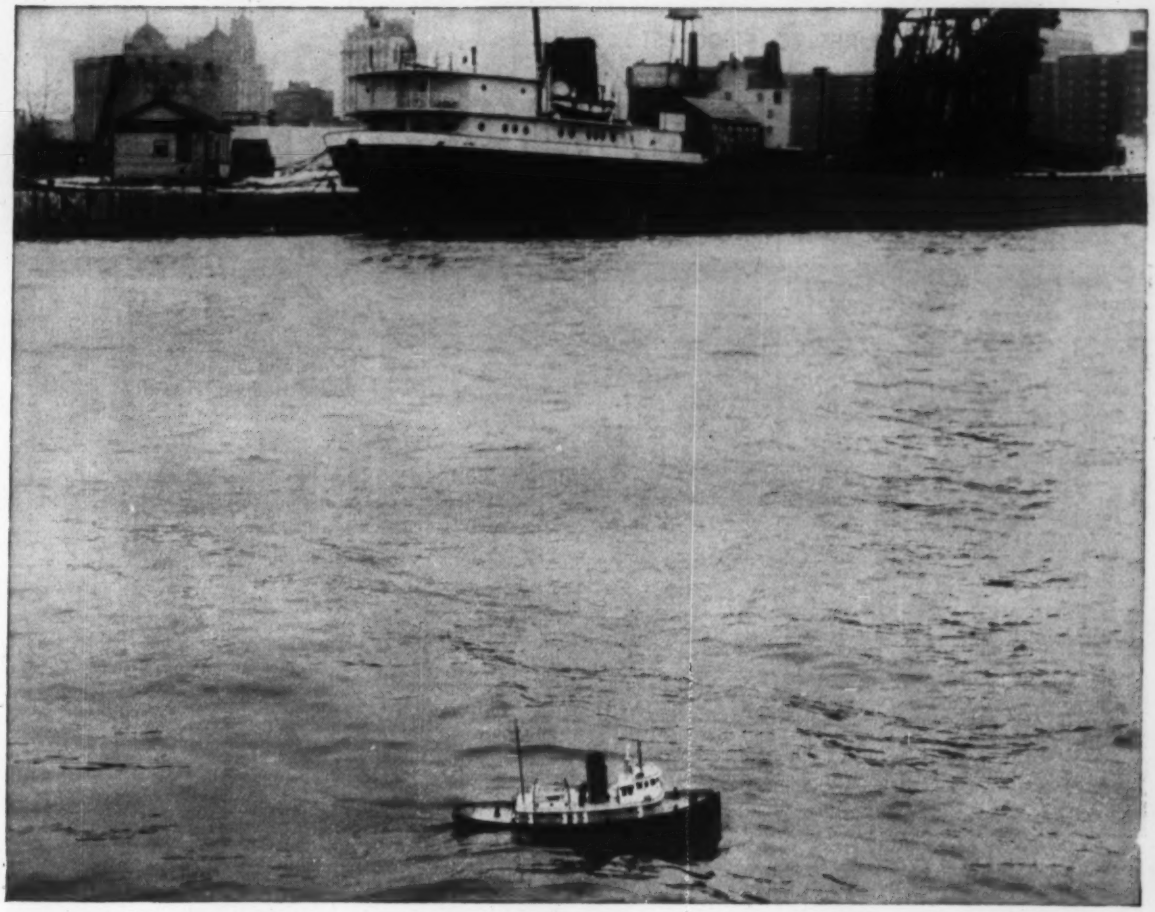


World's smallest Monel shaft delivers model performance

When radio-controlled *Polaris* sets out for a run on the Buffalo River, she's every inch a working tugboat. Although she's only 34 inches long, the river is as rough on her as it is on life-size boats.

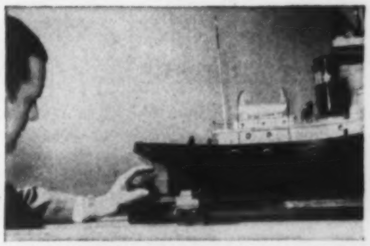
Take her shaft, for example. Her tiny engine delivers brutal shocks to it. Then, when choppy water lifts her stern into the air, the propeller revs up wildly. And big boat or small, when a propeller hits a piece of driftwood—it's trouble.

Like so many of her bigger sisters, *Polaris* was originally equipped with an ordinary metal shaft. And also like so many of her bigger sisters, she used to bend up her shafts. They just couldn't take it.

That's when Polaris' owner equipped her with a Monel* nickel-copper alloy shaft. It's probably the world's smallest . . . just over 4¼ inches long, only ⅛ inch in diameter. It's extra-strong—withstands engine torque. Extra-stiff—shrugs off whip. Extra-hard—stays smoother longer. And, highly corrosion-resisting.

This application of Monel alloy is small, in terms of quantity. But its significance is as big as you make it. That's why we ask . . .

Do you have a metal problem? One where corrosion, abrasion, high or low temperatures, stress or fatigue is causing you trouble? Let's talk it over. There's a very good chance one of the Inco Nickel Alloys may be able to give you the model performance *you've* been looking for. Why not set up a date to discuss it.



Owner-builder H. H. Larkin, Jr. indicates Monel shaft on *Polaris.* When the makers of Veco Products Corp. Kits heard of Mr. Larkin's experience, they switched to Monel alloy for all their shafts.

*Registered trademark of The International Nickel Company, Inc.

The International Nickel Company, Inc.

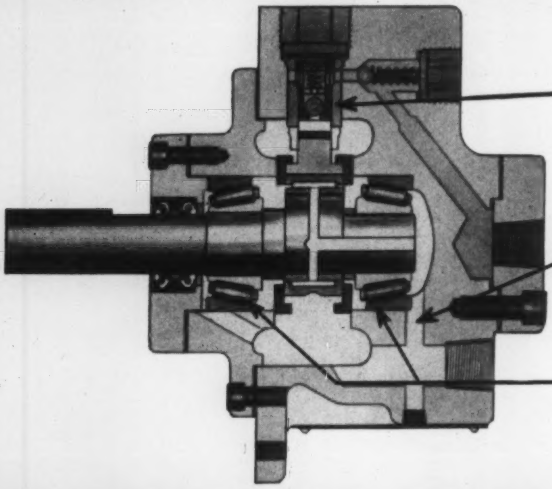
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL ALLOYS

NICKEL ALLOYS PERFORM BETTER LONGER

AT PRESSURES TO 5,000 PSI . . .

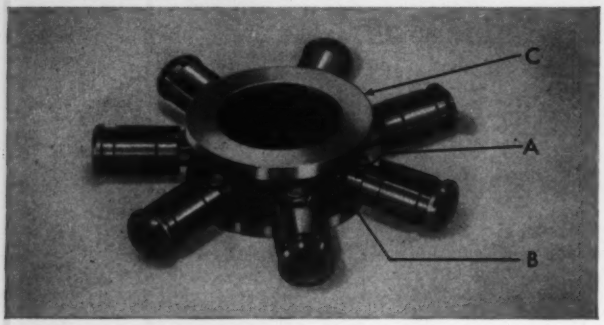
Only the AE Hydramite offers all these advantages



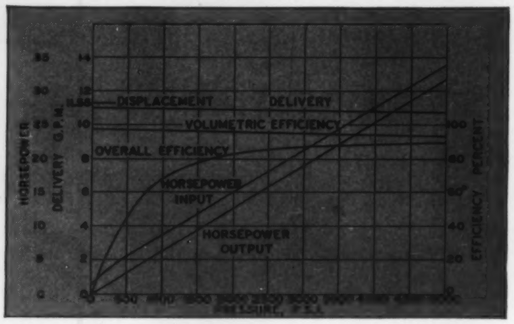
Liners and plungers are honed and individually mated for optimum fit.

Low friction losses. Pump operates with case flooded. Oil is ported to take advantage of natural pumping action of tapered bearings.

Heavy duty, high capacity tapered roller bearings absorb more punishment . . . handle maximum unbalanced loads . . . last longer.

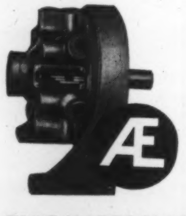


Positive pumping action. The Hydramite has no cam follower springs to fail. Plungers (A) are connected to curved slippers (B) which are held against the outer race of cam shaft needle bearing by two plunger return rings (C). As the shaft revolves, each plunger is pushed outward in succession and then pulled inward by the return rings.



High efficiency. With a Hydramite you get an overall efficiency of 85%. Its flat overall high efficiency curve has little variation between 1,500 and 5,000 psi. What's more with a Hydramite you get positive suction. There is no requirement for supercharging equipment which deducts from system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 30 gpm at 5,000 psi and 70 to 85 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles. Write or call American Engineering Company, Philadelphia 37, Pennsylvania. Phone: Cumberland 9-3800.



AMERICAN ENGINEERING COMPANY

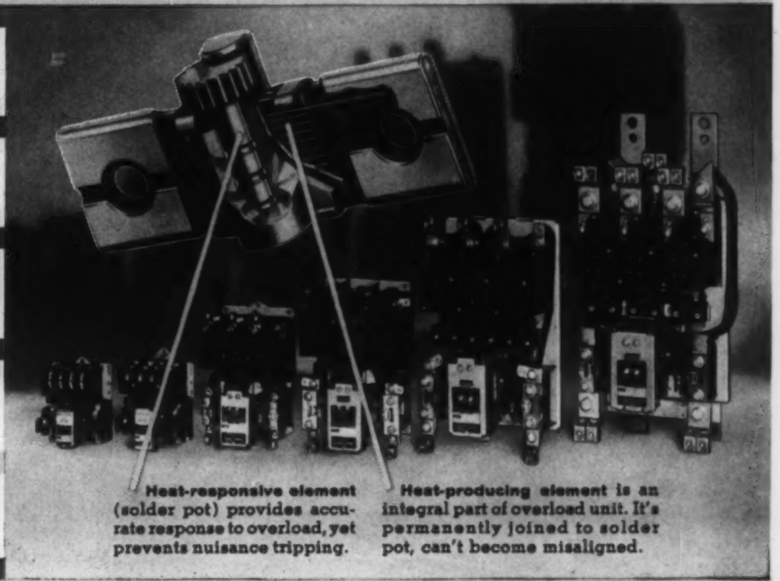
Hele-Shaw Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra Grate, Perfect Spread and Taylor Stokers.

Circle 480 on Page 19

When you buy Motor Starters--

YOU PAY FOR OVERLOAD PROTECTION

...BE SURE YOU GET IT!



Heat-responsive element (solder pot) provides accurate response to overload, yet prevents nuisance tripping.

Heat-producing element is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.

Only ONE-PIECE Overload Relays can give 100% Protection Only with ONE-PIECE construction can you *know* you've installed the heater correctly. Only with ONE-PIECE construction can you *know* the heater is exactly centered, or properly positioned, so that it performs according to its rating. Only with ONE-PIECE construction can you *know* your starters will not operate without the thermal units properly installed. Only with ONE-PIECE construction can you *know* your motors have full protection.

Only Square D has ONE-PIECE Construction ONE-PIECE construction *eliminates* any possibility of heater misalignment. Square D melting alloy thermal overload relays can be installed only one way. They are tamper-proof. They are factory-assembled, are *individually* calibrated and tested. Repeated tripping will not affect their accuracy.

Insist on Square D starters with melting alloy thermal overload relays

LET US PROVE IT!

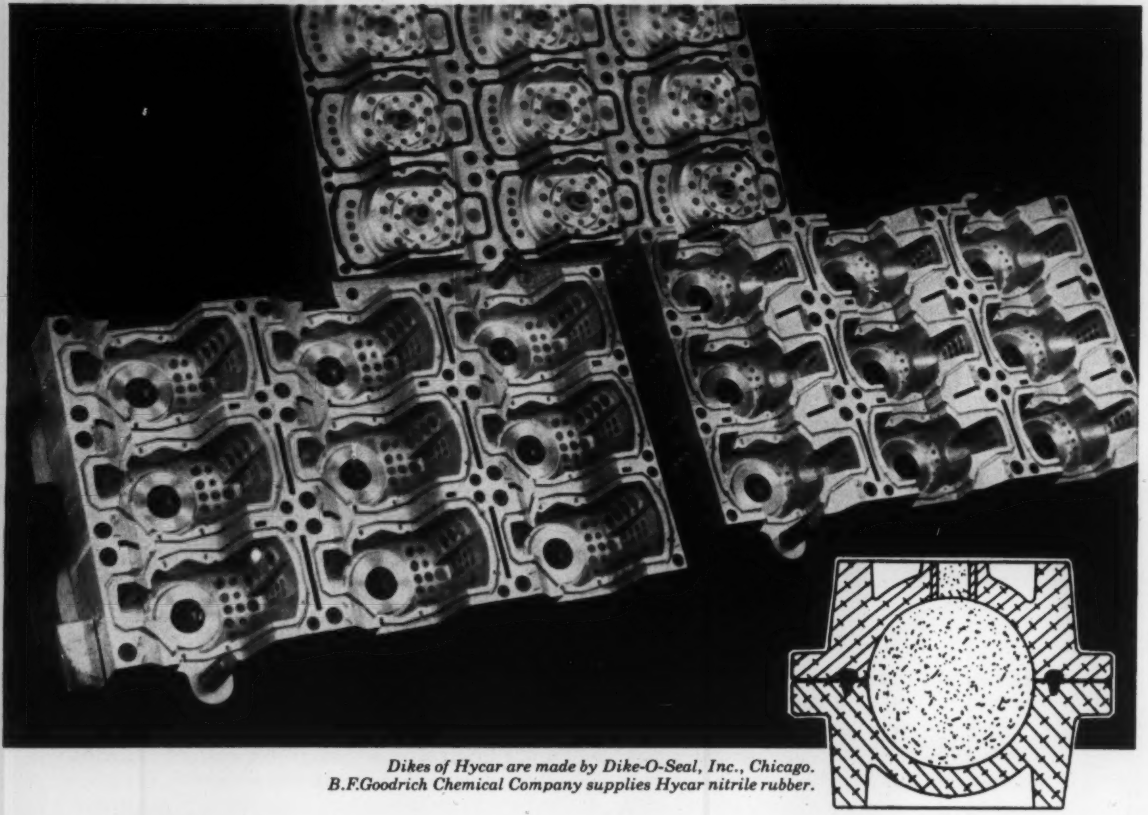
Let your Square D Field Engineer show you ① how one-piece construction is accomplished and how easy it is to mismatch separate heaters and solder pots— ② an endurance tester to prove that overload units can be reset repeatedly without damage while the solder is liquid— ③ a tripping time tester to compare various types of melting alloy units and to prove that tripping time won't change after repeated operation.

Write *for Bulletin SM-275 for the complete story on Square D starters with ONE-PIECE thermal overload relays. Address Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin*

SQUARE D COMPANY

Another new development using

B.F.Goodrich Chemical ***raw materials***



Dikes of Hycar are made by Dike-O-Seal, Inc., Chicago. B.F.Goodrich Chemical Company supplies Hycar nitrile rubber.

Hycar seals go to core of pressing foundry problem

Modern foundry practice calls for cutting costs by blowing sand into core boxes under pressure. The result is a better core and eventually a better casting—but there are problems. Without a perfect seal, operators get a condition called "blow-by", an erosion of core boxes that may result in flaws in the finished casting—as well as damaging the box itself.

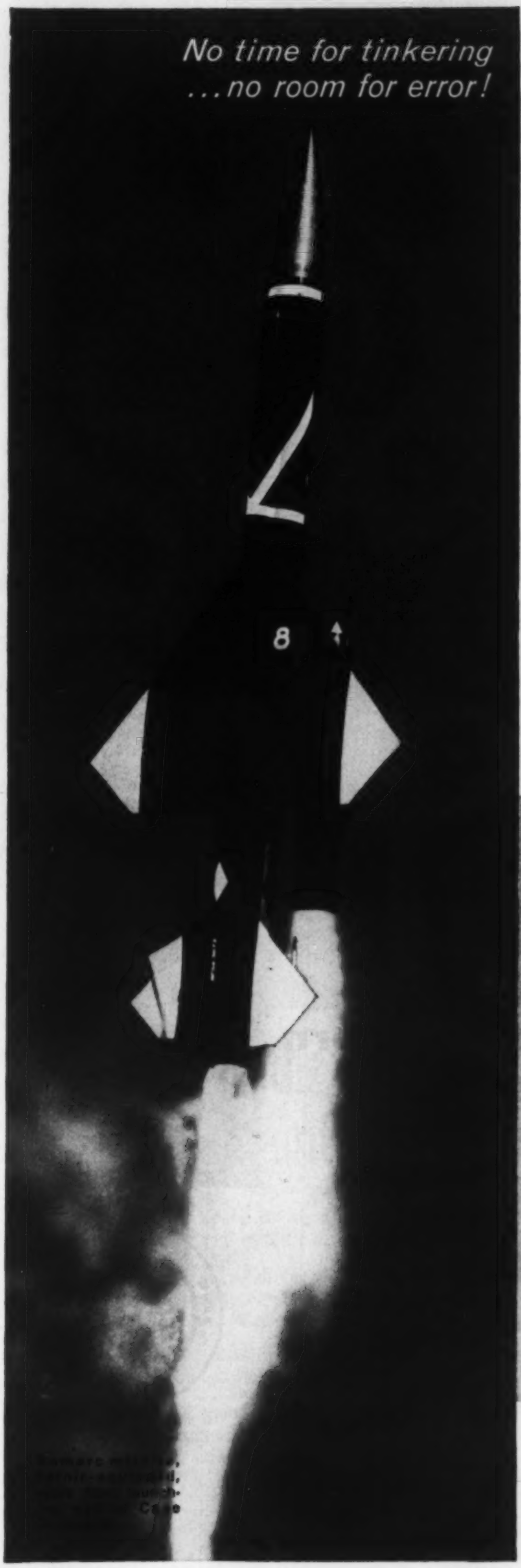
The problem is being solved with flexible Dikes made from Hycar nitrile rubber. These Dikes provide a perfect seal under some tough operating conditions. The Dikes have to be flexible to fit the outlines of complicated core box parting faces. And they stay in place during core box cleaning, exposing them to live steam, alkali or even fuel oil.

Since Hycar retains its resilience under a wide range of temperature and the most severe mechanical deformation, it proved ideal. In addition, it has unusual abrasion resistance and can withstand hydrocarbons and chemicals that destroy ordinary rubber. Hycar may be the material that can help you get more results for your product. For information, write Dept. CM-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
REG. U. S. PAT. OFF.
Rubber and Latex

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers



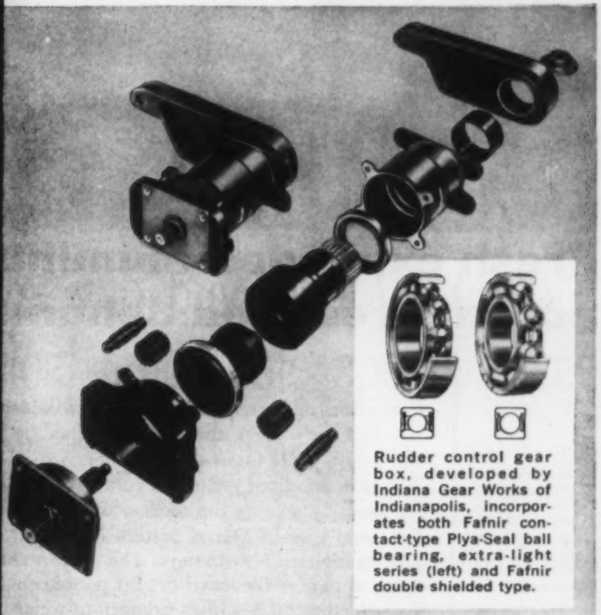
Fafnir Ball Bearings help keep Bomarc missiles "on tap"... and on target!

Used in the outboard rudder control gear box of the Boeing Bomarc, Fafnir ball bearings meet several important design requirements for Indiana Gear Works, designers of this vital missile component.

Fafnir prelubricated and shielded ball bearings and bearings with Plya-Seals, for example, provide positive, built-in protection against contaminants. These bearings remain trouble-free, require no servicing, help keep the Bomarc ready to go at moment's notice.

Uniform high quality is another must. Fafnir quality control insures bearings that consistently meet exacting tolerance and dimensional requirements, installation after installation.

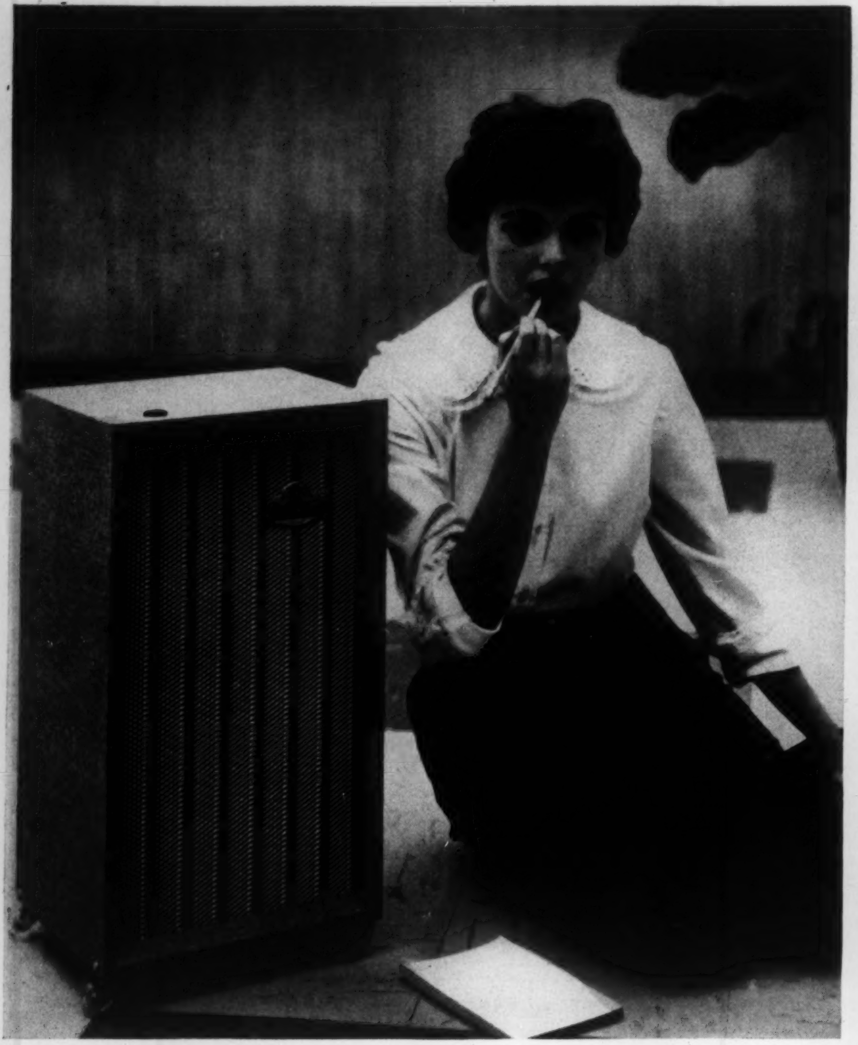
Your own design problem may not involve missilery. But if it calls for ball bearings, look to Fafnir. You'll find the diversity of line and breadth of experience that assure precise answers. Write The Fafnir Bearing Company, New Britain, Connecticut.



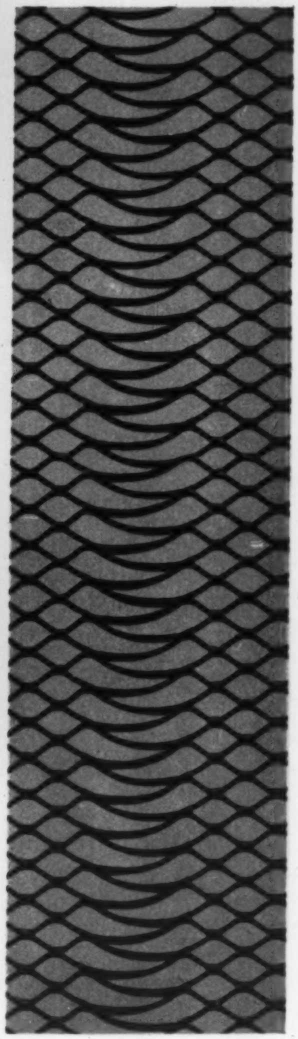
Rudder control gear box, developed by Indiana Gear Works of Indianapolis, incorporates both Fafnir contact-type Plya-Seal ball bearing, extra-light series (left) and Fafnir double shielded type.

FAFNIR
BALL BEARINGS

Circle 483 on Page 19



Oasis Dehumidifier by Ebco Manufacturing Co., incorporates a grille of Penmetal Garland expanded aluminum, shown actual size below.



Fresh expanded-aluminum pattern accents restyled dehumidifier

Clean lines . . . a crisp, new look that will last . . . greater utility . . . these are some of the qualities gained by Ebco designers in re-styling the Oasis dehumidifier.

The rich, anodized grille of Penmetal expanded aluminum handsomely accents the mocha-tweed vinyl-covered cabinet. Penmetal's new Garland pattern has depth and variety . . . is a lasting invitation to the eye. The golden color is an integral part of the metal . . . for permanent brilliance. Expanded metal has high strength-to-weight ratio . . . comes in a number of exciting new patterns. For full details, send for illustrated folder 516-EM.

PENN METAL COMPANY, INC.
90th
YEAR
1869 – 1959

PENN METAL COMPANY, INC.
General Sales Office: 40 Central Street, Boston 9, Mass.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg, St. Louis

PM-216

Circle 484 on Page 19

Ten-second quiz for people who buy, operate or maintain electrical adjustable speed drives

YES NO

☐ ☐ Adjustable speed drives should be simple to install, operate, and should require little or no maintenance.

☐ ☐ Adjustable speed drives should offer a wide range with either constant torque or constant hp, and should offer smooth acceleration and deceleration.

☐ ☐ Adjustable speed drives should offer high operating efficiency . . . and be adaptable to a wide range of motor sizes.

☐ ☐ Adjustable speed drives should provide the required flexibility and inherent reliability for any type of application . . . intermittent or continuous.

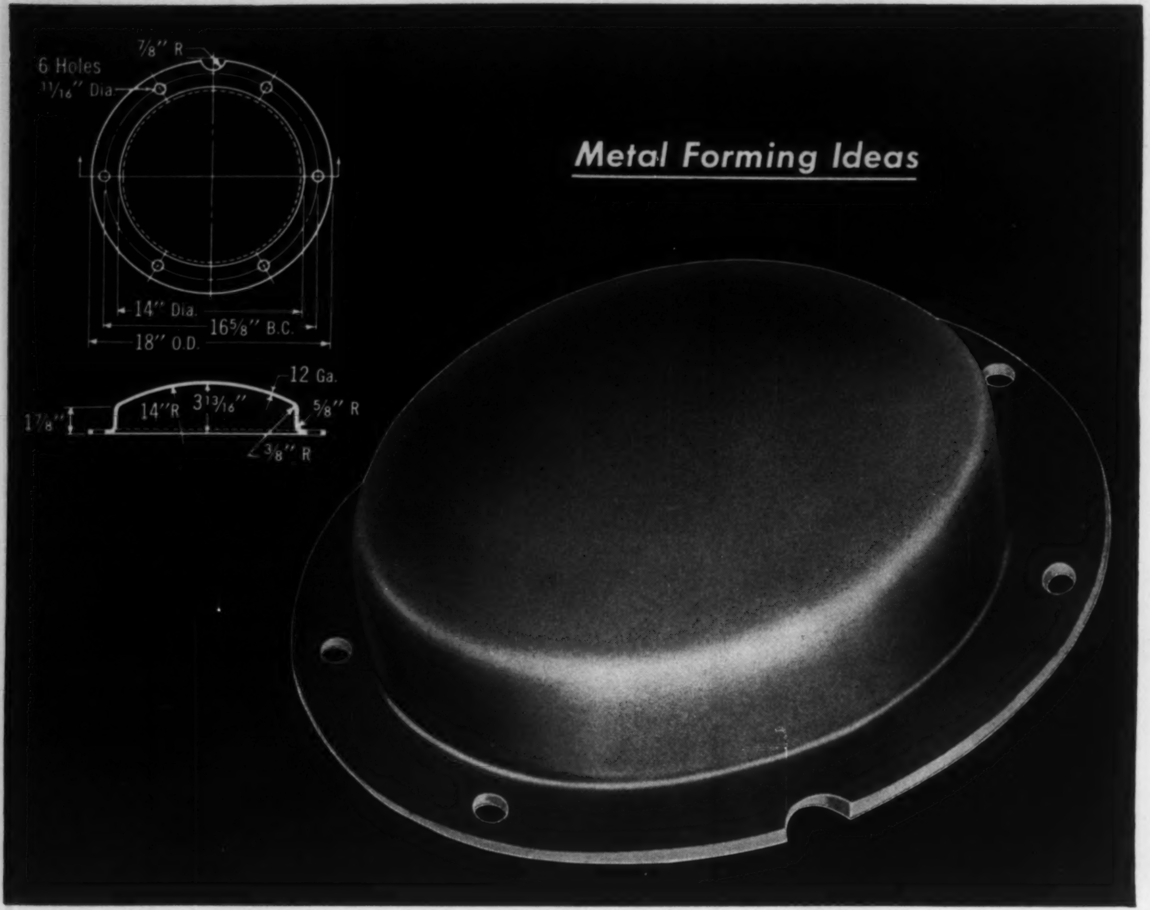
If you have answered "yes" to the above questions, then you will be very much interested in obtaining complete information about the *all-new, static-powered* Westinghouse Adjustable Voltage Reactifier drive . . . (Type AVR). This new drive not only meets all of the above requirements, but also gives you many other advantages to perform a better job at lower cost. Ask your Westinghouse sales engineer to show you exactly where and how this new drive can benefit you. Or, write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

J-22104

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

Circle 485 on Page 19



How to eliminate special tooling in the design of custom-formed parts

Custom stampings, formerly prohibitive cost-wise, can now be inexpensively formed through the use of existing dies from COMMERCIAL's "Die Bank" of almost 50,000 different forming die components.

A case in point: Wheel covers for American Coleman's aircraft towing tractor. They're important for the protection of the power transfer yokes in the tractor's four-wheel drive.

Stamping was first considered as the best method for forming them. The original low quantity involved and the amortization of $2,300 for special forming die costs, however, made the stamping unit costs impractical.

The covers were therefore first produced as machined, malleable iron castings at a cost of $8.49 per unit. A switch to hand spinning later reduced this cost to a still high $3.50 per cover.

American Coleman then discovered and investigated COMMERCIAL's "Die Bank". From 24 basic shapes ranging 4" to 72" in diameter and involving metal thickness from 20 gauge to 3/4"—all available through the use of existing dies adapted to presses up to 2000 ton capacity—emerged an entirely practical and economical solution to the unit cost problem.

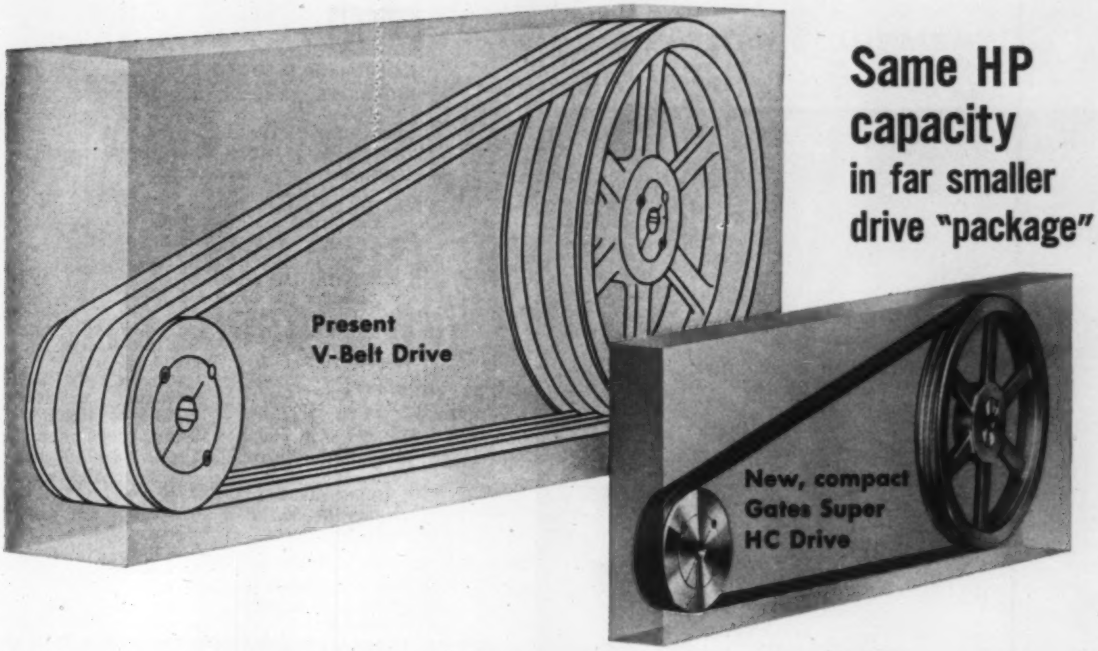
The design: A standard, dished, offset shape with vertical and horizontal flanges and dish radius equal to its dished diameter. The wheel cover of 12 gauge, stamped steel now provides complete protection, necessary yoke clearance and a pleasing appearance.

Best of all, by using an existing forming die from COMMERCIAL's "Die Bank", the actual tooling charge was only $80 for a simple modification of a single die component. And the unit cost was slashed to a practical $2.59.

The final result: A strong, lightweight wheel cover with a smooth surface for finishing which now completely and economically meets all requirements.

If your component requirement involves a custom-formed or unusual shape, and if the high cost of tooling prohibits its economical forming, the "Die Bank" service at COMMERCIAL may be just what you've been looking for. There's a quick way to find out. Just send along a blueprint, sketch or prototype of your part to Commercial Shearing & Stamping Company., Dept. S-24, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping



Same HP capacity
in far smaller drive "package"

New high capacity Gates V-Belt cuts drive space, weight and cost

Reduce size, cut costs! Gates new Super HC V-Belt puts power transmission in a smaller package—cuts costs all along the line!

Actually, this major advance in power transmission—a development of *specialized* research in the world's largest V-belt laboratories at Gates—makes possible the most compact, lightest-weight, lowest-cost multiple V-belt drive you can put on any machine. Sheave diameters can be reduced up to 50%, sheave widths 30% to 50%, center distances 20% and more.

Reduce drive cost as much as 20%

On new drives, the cost of a Gates Super HC V-Belt Drive is as much as 20% under the cost of present V-belt drives of the same hp capacity. Furthermore, smaller housings and bases—less materials, production time, shipping costs all reduce costs still further.

Learn more about the cost-saving Super HC Drive

"The Modern Way to Design Multiple V-Belt Drives" is an informative handbook on the Super HC Drive, available from your nearby Gates Distributor listed in the Yellow Pages under Belts or Belting.

The Super HC V-Belt

transmits same HP in much less space than belts now in use

Shown below are space savings of a typical installation:

	Drive R Sheave Diam.	Drive N Sheave Diam.	Center Distance	No. of Belts
Present Drive	7.4"	20.0"	42.9"	4
Super HC Drive	**5.3"**	**14.0"**	**30.0"**	**3**

TPA 423

Gates

World's Largest Maker of V-Belts

The Gates Rubber Company • **Denver, Colorado**
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates Super HC V-Belt Drives

Circle 487 on Page 19

Silicone Sponge Rubber

remains flexible at extreme temperatures −100° F to 500° F

COHRlastic R-10470 silicone sponge rubber has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, seals, pads, bumpers, dynamic cushions and other applications where resiliency at extreme temperatures is required. It has superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening and good chemical resistance — non-sticking, odorless, non-corrosive.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Sheets 24″ x 24″ and in thicknesses 1/16″ through 1/2″ are available from stock. Larger sizes up to 30″ x 30″ and special molded and extruded shapes are made to order. CHR silicone sponge rubber is sold nationally through distributors.

FREE SAMPLES and folder — write, phone or use inquiry service.

CHR

COHRlastic R-10470
Silicone Sponge Rubber

SPECIFICATIONS:

COHRlastic R-10470 meets many specifications. Some are listed below:

- AMS 3195
- AMS 3196
- MIL-R-6130A type 2
- Boeing BMS 1-23
- Martin MC1 4546
- Martin MB 6130
- Bendix ES 0709
- Douglas DMS 1597
- Lockheed LAC 1-924

PROPERTIES	Range of typical properties COHRlastic R-10470	Typical accepted standards
Tensile	50-130 psi	40 psi, min.
Elongation	175-225%	125% min.
Water absorption (Immersion 24 hrs. @ 75°F.)	3-6%	10% max.
Density, lbs./cu. in.	.020-.030 (firm)	.030 max.
	.013-.018 (medium)	.020 max.
Low temperature brittleness (5 hrs. @ −100°F., bend flat)	No cracking	No cracking
Compression deflection (compressed to 75% of original thickness)		
Room temperature		
Type firm	12-18 psi range[1]	12 min.-20 max. psi
Type medium	8-14 psi range[1]	6 min.-14 max. psi
−65°F. pct. difference	−10% to +15%[1]	
212°F. pct. difference	+5% to +10%[1]	
Compression set (compressed to 50% of original thickness)		
22 hrs. @ 70°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ −65°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ 212°F	10-25% (firm)[1]	30% max.
	20-50% (medium)[1]	60% max.

[1] ASTM D 1056-56T

CHR products include:

COHRlastic Aircraft Products — *Airframe and engine seals, firewall seals, coated fabrics and ducts*

COHRlastic Silicone Rubber Products — *Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber*

Temp-R-Tapes — *Pressure sensitive, thermal curing Teflon and silicone tapes*

Allied Products — *COHRlastic silicone cements and conductive gasketing*

Leader In Fabrication of Silicone Rubber

CHR

CONNECTICUT HARD RUBBER COMPANY

Main Office: New Haven 9, Connecticut

Circle 488 on Page 19

PEAK POWER OUTPUT FOR HEAVY-DUTY EQUIPMENT...

HYDRA-DRIVES®

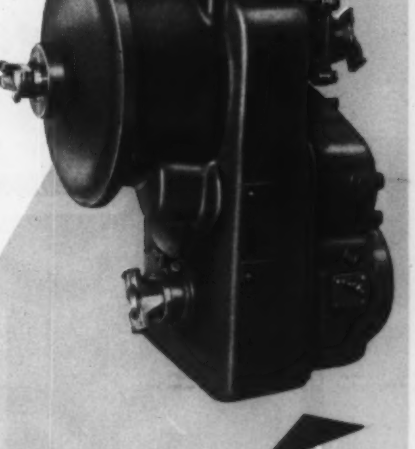
POWER SHIFT TRANSMISSIONS and TORQUE CONVERTERS

Rockwell-Standard's Hydra-Drives units make hard work easy for heavy-duty equipment. The result . . . smooth, efficient, economical operation. A torque converter and 4-speed transmission in one compact package, the Hydra-Drives Power Shift Transmissions have been proved in hundreds of vehicles. They eliminate engine lugging and heavy shock loads. A 3-to-1 torque multiplication makes starting fast and effortless—even with heaviest loads.

Just a flip of the operator's lever accomplishes power shifts without interruption of the power flow. Automatic features of the converter and ease of power shifting simplifies operator training and lengthens vehicle life.

With four speeds forward and reverse, the Hydra-Drives Power Shift Transmissions are ideally suited for vehicles which must travel in both directions during a normal work cycle.

Hydra-Drives Torque Converters are the simplest, most efficient made. They can be matched with any transmission for easier, more efficient operation.

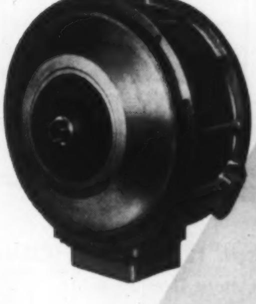


HYDRA-DRIVES BDB Transmission

- Four speeds forward and reverse.
- Full power shifting.
- For equipment up to 175 h.p.

HYDRA-DRIVES CDB Transmission

- Four speeds forward and reverse.
- Power shift in each range both forward and reverse.
- For equipment up to 250 h.p.



HYDRA-DRIVES Torque Converter

- 3-to-1 torque multiplication.
- Available separately, or with Hydra-Drives Transmission.
- For vehicles up to 500 h.p.

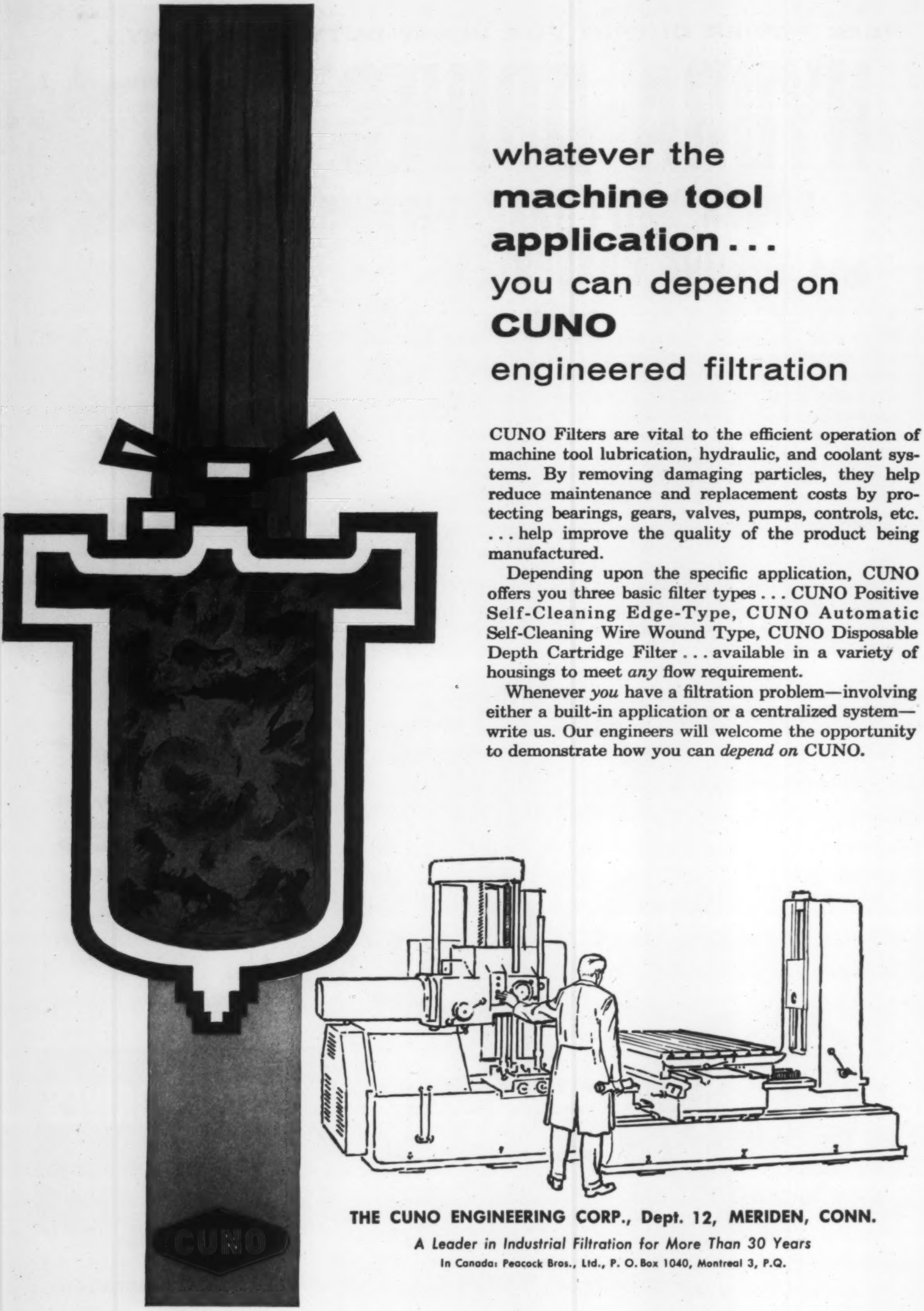
HYDRA DRIVES

ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

R

©1959, R-S Corp.

Products of **ROCKWELL-STANDARD** Corporation



whatever the **machine tool application . . .** you can depend on **CUNO** engineered filtration

CUNO Filters are vital to the efficient operation of machine tool lubrication, hydraulic, and coolant systems. By removing damaging particles, they help reduce maintenance and replacement costs by protecting bearings, gears, valves, pumps, controls, etc. . . . help improve the quality of the product being manufactured.

Depending upon the specific application, CUNO offers you three basic filter types . . . CUNO Positive Self-Cleaning Edge-Type, CUNO Automatic Self-Cleaning Wire Wound Type, CUNO Disposable Depth Cartridge Filter . . . available in a variety of housings to meet *any* flow requirement.

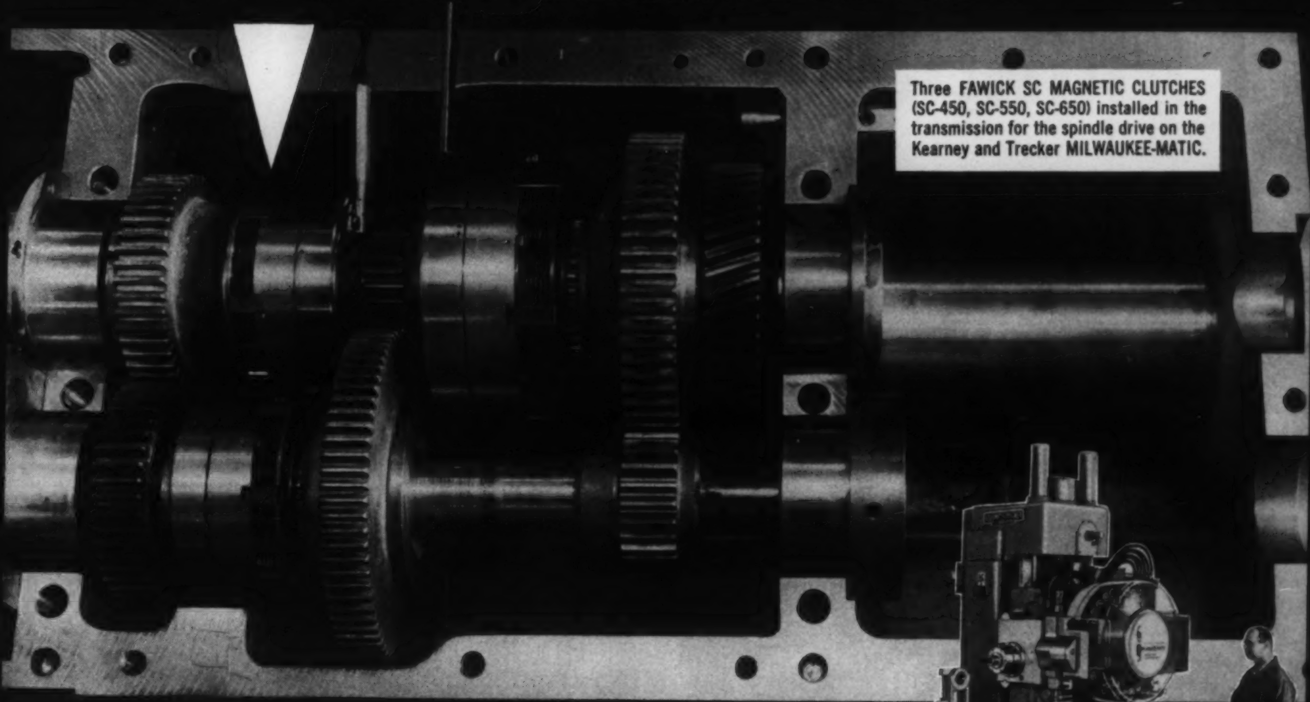
Whenever *you* have a filtration problem—involving either a built-in application or a centralized system—write us. Our engineers will welcome the opportunity to demonstrate how you can *depend on* CUNO.

THE CUNO ENGINEERING CORP., Dept. 12, MERIDEN, CONN.

A Leader in Industrial Filtration for More Than 30 Years

In Canada: Peacock Bros., Ltd., P. O. Box 1040, Montreal 3, P.Q.

Fawick Magnetics here . . .



Three FAWICK SC MAGNETIC CLUTCHES (SC-450, SC-550, SC-650) installed in the transmission for the spindle drive on the Kearney and Trecker MILWAUKEE-MATIC.

contribute to full automation HERE!

Kearney and Trecker MILWAUKEE-MATIC which provides complete, "all-around-the-part" machining in fully-automatic programmed sequence. It accomplishes great cost reductions in tooling, set-up, and machining.

The Kearney and Trecker Milwaukee-Matic is widely acclaimed as a great development in the machine tool industry, providing a flexible, fully-automated machine that produces milling, drilling, reaming, tapping and boring operations in complete sequence on a single machine.

The simple tape "numerical-control" system programs "all-around-the-part" machining with 31 tools, each of which is selected, brought to the work, and changed in scheduled sequence. This makes it possible to completely machine a part without manual changes or removing it from the machine.

Three Fawick SC Magnetic Clutches are used in the spindle head of the Milwaukee-Matic to provide the split-second starts, stops, and reversing actions so necessary to precision timing on this outstanding equipment. These clutches produce instant response to automatic controls, smooth, shock-free operation, full transmission of torque, and long, maintenance-free service life.

This application is typical of many in the machine tool industry, where Fawick Magnetics are establishing new high standards of performance. For full information on the advantages Fawick Magnetics can provide for your equipment call or write your nearest Fawick representative or the Home Office, Cleveland, Ohio.

FAWICK SC MAGNETIC CLUTCH — the high-efficiency clutch supplied complete, ready to install. Torque capacities from 27 to 66,000 inch-pounds.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK
MAGNETIC
INDUSTRIAL CLUTCHES AND BRAKES

Circle 491 on Page 19

O-RINGS
by National
engineering help
fast delivery
uniform quality
Call your National field engineer

National O-Rings are precision made, uniform commercial rings available throughout the United States—promptly! Quality is superior; all ingredients are inspected before compounding and compounding is strictly controlled for maximum uniformity. Molding is done on modern equipment by veterans of 20 years in O-Ring manufacture. Every precaution is taken to insure that no O-Rings with cuts, scratches or mold defects are shipped.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Redwood City
and Downey, California

Atlanta 8, Georgia
George W. Smith Company
394 Williams St., N.W.
JAckson 3-7140

Chicago (Oak Park) Illinois
7001 North Avenue
VIllage 8-4500

Cleveland 18, Ohio
210 Heights Rockefeller Bldg.
3091 Mayfield Road at Lee
YEllowstone 2-2720

Dallas 19, Texas
Benson Engineering Company
2514 West Mockingbird Lane
FLeetwood 2-7541

Detroit 27, Michigan
13836 Puritan Avenue
VErmont 6-1909

Indianapolis 5, Indiana
2802 N. Delaware St.
WAlnut 3-1535

Kansas City (Prairie Village) Kansas
Benson Engineering Co.
2902 West 72nd Terrace
ENdicott 2-2843

Los Angeles (Downey) California
11634 Patton Road
TOpaz 2-8163

Milwaukee 4, Wisconsin
647 W. Virginia Street
BRoadway 1-3234

Red Bank, New Jersey
16 Spring Street
SHadyside 7-3242

Wichita, Kansas
Benson Engineering Company
519 So. Broadway
AMhurst 2-6971

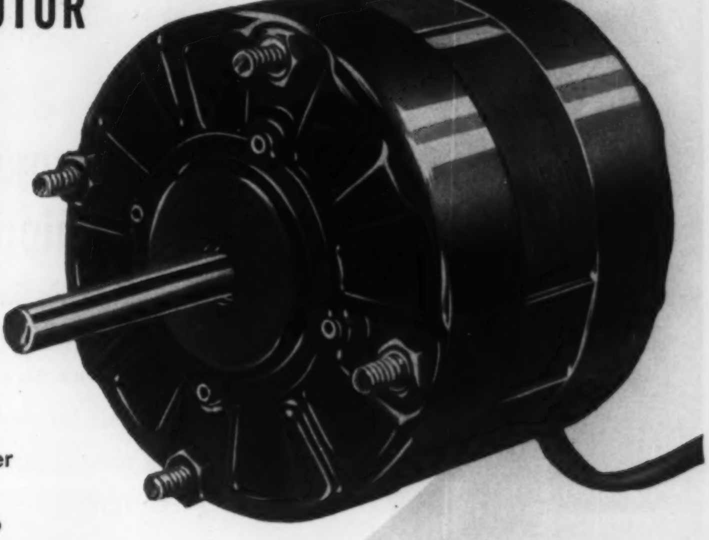
5600

this new TYPE 23

UNIVERSAL ELECTRIC

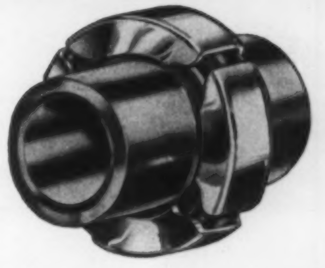
FRACTIONAL HP MOTOR

packs greater power into a smaller motor



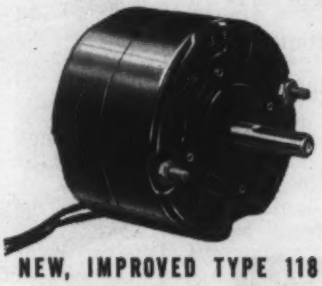
handles jobs formerly requiring larger, more expensive units

UNIVERSAL ELECTRIC announces a new 4-pole, shaded pole fractional HP motor . . . the TYPE 23 . . . which provides greater power than previous motors of larger dimensions. Available in sizes from 1/50 to 1/12 HP. The improvements that have made this motor more efficient are newly designed laminations, improved rotor construction, improved material processing and the new, *free-aligning* **Universal Bearing.**



This revolutionary new free-aligning Universal Bearing* eliminates fractional HP motor problems due to misalignment. It is always in balance and can adjust to shaft misalignment 100% of the time under any load conditions. Provides longer bearing life, better lubrication, easier starting and quieter operation. Now being used in the new TYPE 23 and the redesigned TYPE 118 UNIVERSAL ELECTRIC motors.

*PATENT APPLIED FOR



NEW, IMPROVED TYPE 118 FRACTIONAL HP MOTOR

More rugged and precision built from highest quality materials, the redesigned TYPE 118 motor . . . available in sizes from 1/200 to 1/50 HP . . . is ideal for applications requiring maximum dependability and long life. Depending on power requirements, both the TYPE 118 and TYPE 23 motors are ideal for kitchen ventilators, unit heaters, tape recorders, refrigeration equipment, record players, pump units, etc.

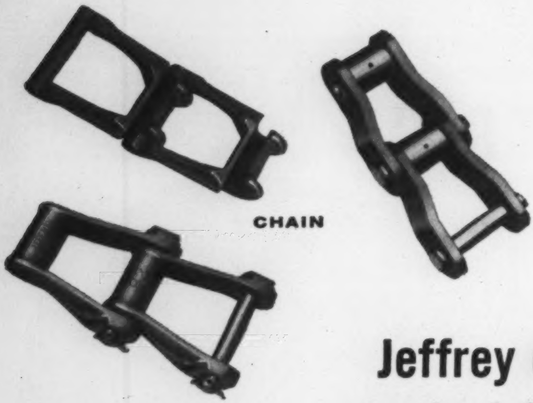
Write for complete information on UNIVERSAL ELECTRIC TYPE 118 and TYPE 23 fractional HP motors and the new free-aligning **Universal Bearing.**

UNIVERSAL ELECTRIC COMPANY

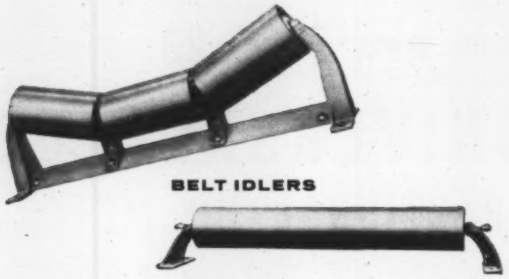
PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10

Circle 493 on Page 19



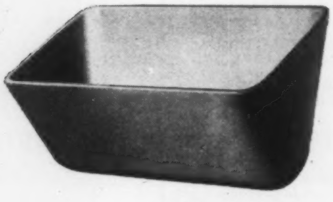
CHAIN



BELT IDLERS

Jeffrey equipment stocked for shipment

SPROCKETS

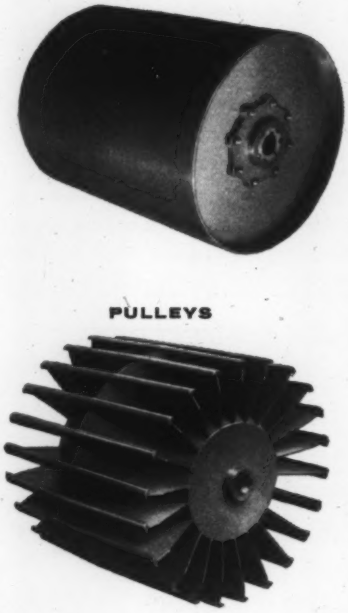


BUCKETS

From factory or distributor stocks you can get fast service on a host of Jeffrey products...for elevating and conveying machinery and many industrial applications.

When replacing parts or modernizing machinery, it's wise to use genuine Jeffrey equipment. Highest manufacturing standards, based on years of experience, assure dependable performance. For service, call your Jeffrey distributor or write The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

PILLOW BLOCKS



PULLEYS

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CONVEYING • PROCESSING
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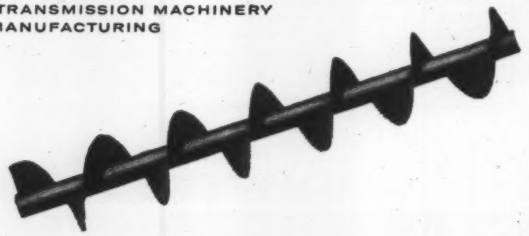

SPIRAL CONVEYORS

***NOW** — from General Electric . . .*

A complete PLUS LINE of low-speed drives 1/8 to 200 hp!

You save time, money when you get all your mechanical power transmission equipment from one source — General Electric!

General Electric now offers a complete PLUS LINE of compact mechanical power transmission equipment in a wide range of ratings to meet all your low-speed drive requirements! All units available on short shipment—many directly from stock!

G-E PLUS LINE equipment is easy to install—saves you time . . . requires almost no maintenance—saves you money! Line features shaft-mounted and helical speed reducers; integral-type gear motors in right-angle, offset and concentric-shaft designs and all-motor gear motors of more compact, flexible design to save you space, multiply unit uses.

SHAFT-MOUNTED SPEED REDUCERS—ratios 5:1 and 15:1; ¼ to 40 hp; 420 to 10 rpm.
HELICAL SPEED REDUCERS—1 to 200 hp, with gear ratios from 5:1 to 130:1.
ALL-MOTOR GEAR MOTORS—1 to 75 hp, for output speeds from 520 to 13.5 rpm.
INTEGRAL-TYPE GEAR MOTORS—⅛ to 75 hp for output speeds from 780 to 13.5 rpm.

To put the G-E PLUS LINE to work for you, contact your nearby G.E. Apparatus Sales Office or Distributor, or write for bulletins: G-E Helical Gear Motor Line (GEA-6704), Shaft mounted Speed Reducers (GEA-6616), Fractional Horsepower Gear Motors (GEA-6133A), Section 851-9, General Electric Company, Schenectady, N. Y.

And you get these PLUS VALUES...

1. **Product application service.**
2. **Prompt sales service.**
3. **Expert after-sales service.**
4. **One product source.**
5. **Wide product selection.**
6. **Immediate delivery.**
7. **G-E reputation. Advanced product design through research.**

GENERAL ELECTRIC

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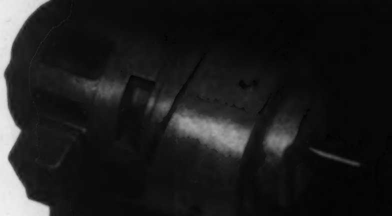


Integral-type gear motor

All-motor gear motor

Right-angle shaft gear motor

Offset-shaft gear motor

New helical speed reducer

New shaft-mounted speed reducer

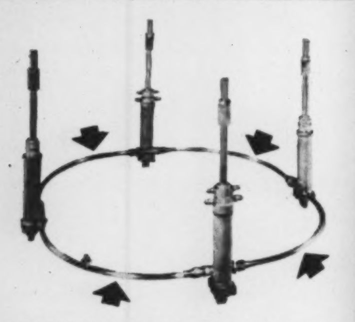
S.S.White

DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with flexible shafts

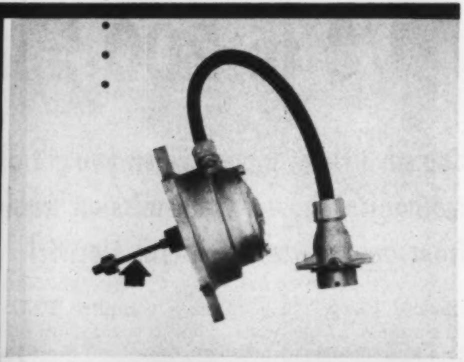
REMOTE CONTROL

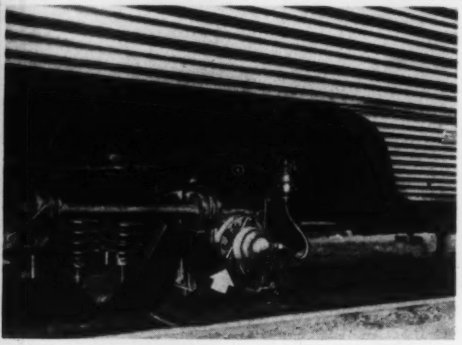
Reliable synchronization at high temperature is made possible by S. S. White flexible shafts on this actuator system for jet afterburner nozzles. The job assigned the shafts was to synchronize the system to permit multipoint installation and smooth, even application of power . . . at ambient temperatures up to 650F! To see how flexible shafts simplify design, picture doing this with solid shafts, gearing, universals, and other paraphernalia, around a 360° bend . . . and then imagine installing it!



POWER DRIVE

Running cool at 45,000 rpm! The S. S. White flexible shaft on this grinder-miller permits the use of carbide and diamond tools at speeds that were previously unknown to hand tools. The flexible shaft drives the handpiece from a ¼-hp motor suspended over the table at speeds up 45,000 rpm, without overheating and without vibration. A good point for designers to note is that in many cases, the higher the speed of a flexible shaft, the better the performance.





COUPLING

Alignment and vibration problems are solved by an S. S. White flexible shaft on this railroad brake controller. The device detects wheel slippage during braking, by means of rotary switches on each axle that detect changes in relative movement between pairs of wheels on the truck. If damaging slip occurs, the device releases brake pressure until slippage stops. A flexible shaft is fitted to the axle and drives the rotor in the switch, eliminating alignment problems and preventing excessive axle vibration from reaching the sensitive device.

1056

S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION (Dept. 4)
10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Blvd., Los Angeles, Calif.

Standard S. S. White flexible shafts are available "off the shelf," making many savings possible.
Write for bulletin 5801.

USEFUL DATA ON SELECTION and APPLICATION!

S. S. White also offers engineering service and comprehensive selection of flexible shaft sizes and types to meet special requirements.
Write for bulletin 5601.

Circle 496 on Page 19

Now, from the Laboratories of CLARE,

THE MOST EXCITING RELAY DESIGN OF THE YEAR

NEW *SIX-IN-LINE* **HG6F** RELAY BRINGS BIG SAVINGS IN SPACE, POWER, AND COST

Latest in the Clare line of Mercury-wetted Contact Relays, world famous for their billions of operations*, is Type HG6F, a six-in-line flat-pack relay. This striking new design provides the most reliable, durable, maintenance-free relays ever made anywhere, *plus these savings.*

SAVES SPACE–

Unique packaging affords up to 50% savings in space over cylindrical multi-element mercury-wetted contact relays.

SAVES POWER–

Six switches per coil saves operating power.

SAVES COST–

Switch cost as much as 26% below cost of same number of switches in cylindrical packages.

MERCURY WETTED CONTA...
TYPE HG6F
1002
BOTTOM VIEW
C.P. CLARE & CO.
CHICAGO

Compact CLARE TYPE HG6F Relay ready for mounting. Overall dimensions: 3.640" x 3.125" x 1.046".

*Mercury-wetted contact relays on test have completed over 8 billion operations with a contact-load of 250 volt-amperes, and are still going strong.

MECHANICAL FEATURES

Flat, rectangular package makes most efficient use of chassis space.

Printed circuit mounting eliminates customary internal wiring except for coil leads.

Units can be stacked in line without interaction.

No shelf deterioration; requires no maintenance.

Contacts cannot wear, get dirty, stick by locking or welding, nor chatter.

Tamper proof.

Completely protected against dust and dirt, corrosive fumes, and explosive atmospheres.

No mechanical damage when subjected to usual military shock and vibration tests.

ELECTRICAL FEATURES

Life expectancy measured in billions of operations.

No contact chatter or bounce.

Low and consistent contact resistance.

Full line of coil resistances.

Contacts rated at 5 amperes, 500 volts (d-c or rms)

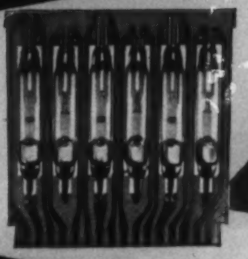
Product of voltage prior to closing and current prior to opening, 250 volt-amperes maximum.

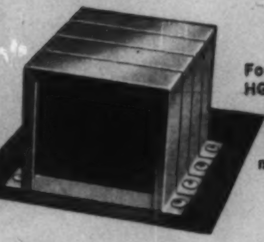
Nominal operating time: 1 watt input, 11 milliseconds; 2 watts input, 7 milliseconds; 4 watts input, 5 milliseconds.

Release time: 4 milliseconds or less. Maximum continuous dissipation: 5 watts at 100° F.

Circle 497 on Page 19

Arrangement of six-in-line mercury-wetted contact switches on printed circuit panel.





Four CLARE Type HG6F relays mount in a space 50% less than cylindrical multi-element assemblies.

SEND FOR BROCHURE CPC-2

For complete information, contact C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY

CLARE RELAYS

FIRST in the industrial field

What a build!

... solid state components in New Fenwal Temperature Controller combine precision with extra reliability

Here's a new, low-cost temperature controller that's really built "solid": thermistor sensing element, printed circuit, transistors. *No wonder the Fenwal 535 Temperature Controller provides high precision, trouble-free operation and long life!*

The Model 535's solid state components pay off in simplicity and dependability. The thermistor sensor mounts up to hundreds of feet from the controller using uncompensated electric wiring; has virtually limitless life; feeds into a rugged transistor amplifier. *No moving parts . . . nothing to wear out!*

The Model 535 is the latest advance in the low-cost line of Fenwal Temperature Controllers specifically developed to fully exploit the advantages . . . rapid response, compact size, reliability . . . of solid state components. *And Fenwal, alone, has integrated production of both controllers and thermistors.*

Use the Fenwal Model 535 Controller for fast response and close control of temperatures from −25°F to +600°F in plastics, packaging, or other critical applications. Get full details from a Fenwal Sales Engineer or write for catalog. Fenwal Incorporated, 196 Pleasant Street, Ashland, Mass.

Single point Model 535 Fenwal Temperature Controller has 2°F setting accuracy and sensitive operating differentials from 0.4°F to 1.2°F. Current capacity: 5 amps. 115 volts AC — 10 amp. model later in 1959.

ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

D'Arazien

Alcoa puts the metal where you want it

In less time than it takes you to say "Impact," even the longest of these impacts can be fully formed and flawlessly finished—longitudinal hole, closed end and all—from a single slug of Alcoa® Alloy 6061-T6. Impacts, produced to tolerances as close as plus or minus 0.0005 in. without *any* further processing . . . with smooth, ultra-hard, corrosion-resistant finish 125 microinches both inside and out.

The above pictorially represents the growth of the finished part which, as produced, is approximately 16 in. long: a missile hydraulic component made by Alcoa for Vickers, Incorporated. It represents savings that are scarcely short of fabulous.

Estimate for yourself what it would cost to produce such a form by laborious machining from bar stock—the only practical alternative. Include all the labor of rough-cutting, precision machining and final finishing—*and* the costly waste of metal.

Does this suggest impressive savings? Undoubtedly! But not necessarily more impressive than those you can gain if you consider Alcoa Impacts whenever you need: any closed-end or tubular component, of whatever shape, with such additions as external or internal fins, ribs or bosses . . . and with the highest strength attainable in any given alloy. Separate finishing operations are always reduced to virtually zero, and tooling-up costs are surprisingly low. The more you know about impacts, the more uses—and savings—you'll find in your own production. For eye-opening data, write to: Aluminum Company of America, 918 Alcoa Building, Pittsburgh 19, Pennsylvania.

Alcoa puts the metal where you want it—in castings, forgings, extrusions, screw-machine parts and impacts.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

A plant built on the philosophy of "don't accept anything at face value"...

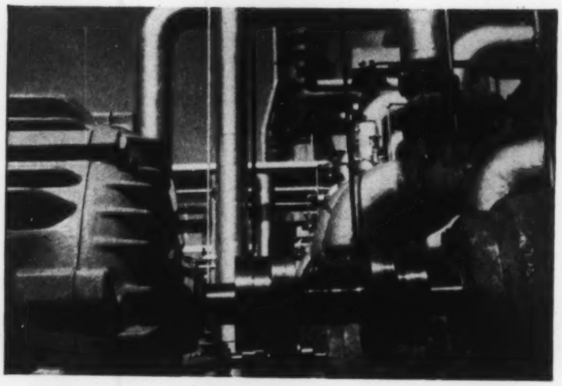
Tidewater's "Refinery of the Future" Uses 471 Fast's Couplings to Reduce Maintenance

IN PLANNING Tidewater's Delaware Refinery, all equipment purchases were examined from every angle . . . capital investment, manpower, maintenance and reliability. Fast's Self-Aligning Couplings were used throughout because they met Tidewater's exacting demands.

Tidewater's equipment design policies were established by survey teams that visited refineries all over the country. They carefully appraised each plant and asked operators what improvements they would make and what features they would retain if they were to redesign their drives.

In 471 applications at this refinery, Fast's Couplings guarantee mechanical flexibility that eliminates costly shutdowns and expensive shaft replacements. Fast's have the reputation of frequently outlasting the equipment they connect. This means savings in maintenance and down-time . . . in addition to protecting costly equipment against errors of alignment.

Nearly 40 years of coupling experience qualifies Koppers to solve *your* coupling problem. Write today for full details to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 5606 Scott Street, Baltimore 3, Md.



Fast's Couplings give dependable, trouble-free service throughout Tidewater's entire production facilities.

This Fast's Coupling drives a pump delivering heavy naptha to the Solutizing plant.

Engineered **Products**
Sold with *Service*

KOPPERS

THE ORIGINAL
FAST'S Couplings

Circle 500 on Page 19

MACHINE DESIGN

June 11, 1959

How Right Is Right?

IT'S a pretty good bet that you won't get killed by a tornado today. More exactly, the probabilities are 99.99999976 per cent against it. And you can be pretty sure that today you won't

Get robbed	99.999902%
Have your car stolen	99.9986%
Be injured in an accident	99.984%

These probabilities are so high that, in our daily existence, we act as if they're absolute certainties. You don't hire a guard to watch your parked car, nor do you insist on working in the nearest storm cellar.

Wouldn't it be an easy life if engineering problems had such clear-cut answers? They don't, of course. Yet an engineer has to be right. The main question is—how right?

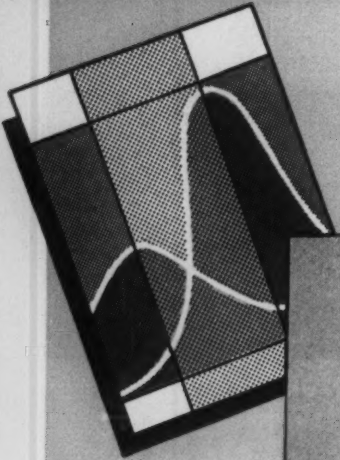
It has been said that an executive only has to be right 51 per cent of the time to be successful. A more common confidence level, for engineers, might be 95 per cent, as suggested by Bill Hyzer in his article starting on the next page.

Certainly there's enough variability to suggest that there's no one "best" confidence level for making a decision. The engineer who always wants to be 99+ per cent right can waste valuable hours on trivial decisions. But patching up the mistakes of an engineer accustomed to making snap judgments (at a 50 per cent confidence level) can be a costly process.

The problem is to develop a built-in flexibility, so that each decision gets just the care and attention it deserves. In any case, there's one consolation: Even under the stress of deciding a tough one, you can be 99.99971 per cent sure you won't wind up in a mental institution—that is, not today!

Robert L. Stedfeld

ASSOCIATE MANAGING EDITOR



A simplified approach to
ENGINEERING
based on statistical methods

WILLIAM G. HYZER
Consulting Research Engineer
Janesville, Wis.

Do actual values recorded in a test accurately represent the effect being measured? Is an extreme numerical variation observed in an experiment a true effect or just the result of random error? Are enough "test points" being used for accurate answers?

Are you tired of guessing at the answers to these vital questions? If so, here in "cookbook" form, are some clear-cut, do-it-yourself recipes for finding highly reliable answers with a minimum amount of testing and data analysis. Included are fundamental formulas and easy-to-use charts, based on sound statistical techniques, for assessing experimental results.

STATISTICAL techniques, properly used, are extremely valuable tools in setting up and analyzing experimental data in research and development work. They are effective in studying test results which compare different parts, materials, or processes specified in design.

Unfortunately, the strongest deterrent in using statistical tools is the complexity of the terminology and techniques. This series of two articles explains in simple terms general principles and short-cut methods which are suitable for most experimental-analysis problems. Part 1 of this series will cover single-factor experiments, while Part 2 will deal with the more complex multiple-factor experiments. A background in statistics is not needed.

Data Confidence Levels

One of the initial problems an investigator faces in setting up an experiment is how to design it to yield the maximum amount of information with the minimum amount of testing effort. Naturally, a certain degree of risk is involved in interpreting any test, whether much data are taken or little. How many readings should be taken before the results can be trusted? The answer to this question is really important, because it is seldom practical to conduct an experiment of such magnitude that the results can be trusted completely.

Therefore, before executing an experiment, the investigator should establish in advance a level of confidence to be used in accepting or rejecting the

setting up and interpreting EXPERIMENTS

Part 1 — Single-Factor Experiments

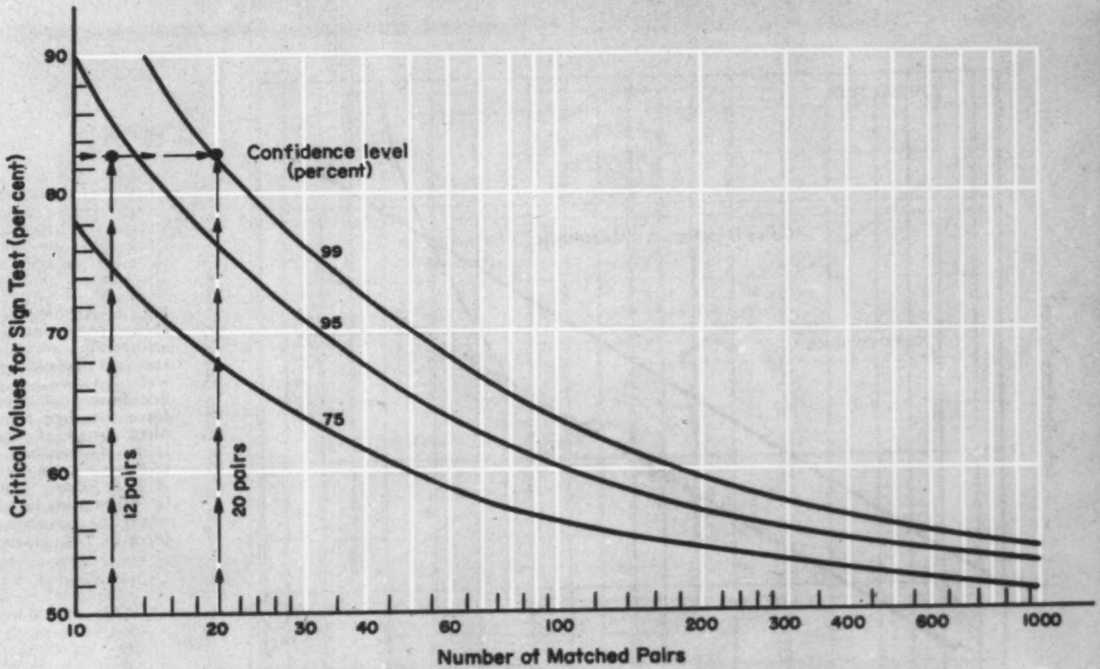


Fig. 1—Chart for determining confidence level of sign test. Ordinate is percentage of pairs in which experimental samples "exceed" the control samples.

apparent conclusions of his data. Confidence level is a percentage risk an investigator is willing to take of drawing a wrong conclusion from the data.

On one hand, he must guard against calling an effect real when it does not exist. This is known as an error of the first kind. On the other hand, he must be careful not to neglect an effect as insignificant when it does really exist. This is termed as an error of the second kind.

Take, for example, an experiment conducted to determine the merits of a new heat-treating method on cam-follower wear. If a 95 per cent confidence level is selected, there is a 5 per cent chance of being misled by the experimental result that the new treatment offers no improvement.

If the choice of confidence level is too low, chance variations in wear might be interpreted as real effects; if too high, the chance of detecting a real difference between the two treatments is reduced. A 95 per cent confidence level is normally considered an adequate compromise for most industrial applications.

Sign Test

Experimental results cannot always be expressed in numbers, but it is possible in many cases to match experimental samples with their controls and directly compare the items qualitatively in pairs. Controls are similar test specimens subjected to the same

How To Find Significant Differences Between Experimental and Control Samples

1. Select a confidence level.
2. Establish a control to be used as a basis for comparison.
3. Take a random sample from the control and experimental lots.
4. Determine the arithmetic mean and standard deviation for both samples from Equations 1 and 3, respectively, or from a plot on arithmetic probability paper.
5.* Reject erroneous observations with the chart in Fig. 4 and recalculate the arithmetic mean and standard deviation.
6. Determine error of the mean from Fig. 5.
7. Calculate error of the difference between means from Equation 4.
8. Compare difference value in Step 7 with observed difference between the means to see if these differences are significant.

*Before this step is taken, the data can be subjected to the sign test which shows whether the experimental samples exceed the controls and to what level of confidence.

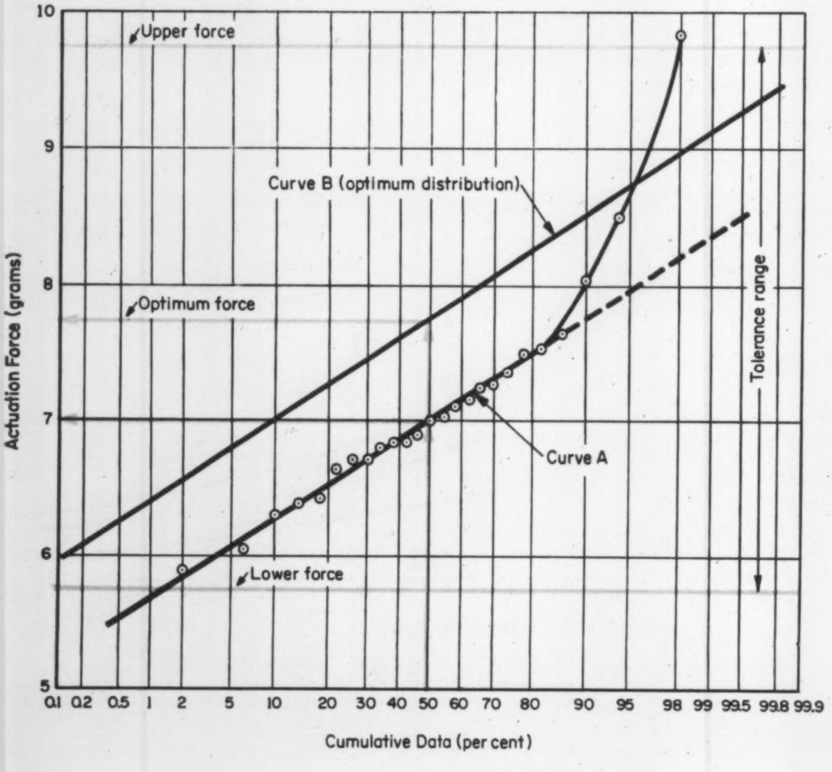


Fig. 2—Arithmetic probability paper for finding arithmetic mean and standard deviation graphically. Curve *A* shows distribution of actuation forces required for a 25-piece sample of precision latch mechanisms. The arithmetic mean for curve *A* is 7 grams. Curve *B* is for optimum design where the mean actuation force is 7.75 grams.

treatment as the objects under experimental investigation, except for the variable under study.

The selection of pairs must be completely randomized, and the comparisons made without bias. This type of experiment is used to answer the twofold question: Do the experimental samples exceed the controls or are they in some ways inferior? This test is called the sign test. Fig. 1 shows the percentage of pairs in which the experimental samples must exceed the controls to be significant at the 75, 95, and 99 per cent confidence levels.

Take, for example, the cam-follower-wear problem mentioned previously. For sake of illustration, assume that degree of wear cannot be measured quantitatively, but the effects of wear are visually evident on the parts produced. Assume that a test is set up to compare the degree of wear on each of several cam followers heat-treated by the old and new methods after 1000 hr of operation on a test machine. This test determines one of three possibilities: 1. If any effects observed are the result of chance. 2. If the new method is more effective than the old. 3. If the new treatment is actually harmful.

Pairs, consisting of a cam follower heat-treated the new way and a similar part heat-treated the old way, are selected at random. A part is selected from each pair that appears best from the effects of operational wear. If both parts in a pair are judged equal, they can either be omitted from the results, or if more than one tie occurs, they can be split half and half. There is strong argument in favor of omitting all ties from the results, a procedure preferred by the author.

In 10 out of 12 or 83 per cent of the cases, the new heat-treating method results in the least wear. From Fig. 1, this result is considered valid at just below the 95 per cent confidence level. The designer can be more than about 90 per cent, but not quite 95 per cent confident that the new process offers improvement, but the results probably should be confirmed by further testing.

The advantage of using a larger sample size is evident in Fig. 1. If one more pair of cam followers are compared, and the part heat treated by the new process proves superior in this comparison, a significant improvement is evident at the 95 per cent confidence level. Note that if this same percentage of improved samples could be obtained for 19 pairs, the results would be 99 per cent significant.

Statistical Building Blocks

All numerical data, no matter what degree of care is taken in their determination, are subject to error. If a large number of small errors act independently to vary the determined value of a partic-

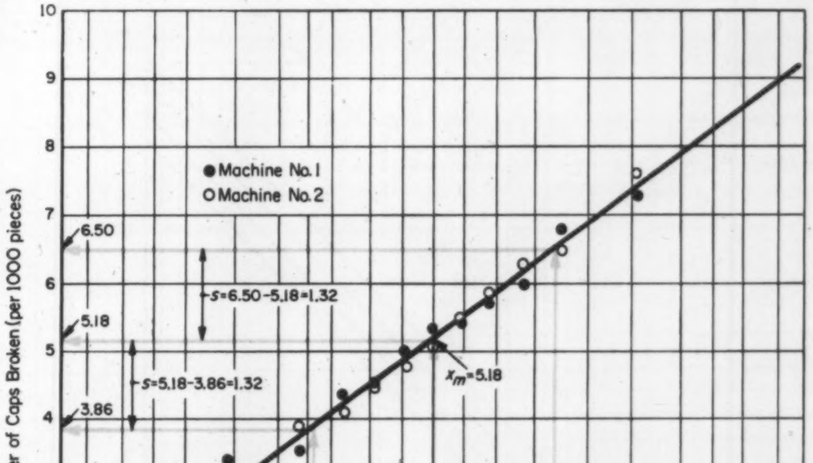


Fig. 3—Statistical analysis on arithmetic probability paper comparing cap breakage on two bottling machines. Data are from 11 observations on each machine. The obvious conclusion is that the amount of cap breakage on machine No. 1 is equivalent to machine No. 2. In a normal distribution, 68.3 per cent of the values are included between a distance equal to one standard deviation on both sides of the arithmetic mean. For two standard deviations, 95.5 per cent are included. For three, 99.73 per cent. Note that 68.3 per cent of the data lies between the 15.85 and 84.15 cumulative per cent points, which equals a distance of one standard deviation on either side of the arithmetic mean.

Table 1—Comparison of Cam-Follower Wear Using Two Different Methods of Heat Treating

Observation No.	Old Treatment x (0.001 in.)	x^2	New Treatment x (0.001 in.)	x^2
1	0.55	0.3025	0.32	0.1024
2	0.65	0.4225	0.50	0.2500
3	0.58	0.3364	0.40	0.1600
4	0.45	0.2025	0.15	0.0225
5	0.60	0.3600	0.45	0.2025
6	0.53	0.2809	0.30	0.0900
7	0.62	0.3844	0.47	0.2209
8	0.47	0.2209	0.25	0.0625
9	0.56	0.3136	0.35	0.1225
10	0.66	0.4356	0.55	0.3025
11	0.59	0.3481	0.42	0.1764
12	0.93	0.8649	0.65	0.4225
Totals	7.19	4.4723	4.71	2.1347
New totals omitting No. 12	6.26	3.6074		

$$x_m = \frac{\Sigma x}{n} = \frac{7.19}{12}$$

$$x_m = 0.6(0.001 \text{ in.})$$

$$s = \sqrt{\frac{\Sigma(x)^2 - \frac{(\Sigma x)^2}{n}}{n-1}}$$

$$s = \sqrt{\frac{4.4723 - \frac{(7.19)^2}{12}}{12-1}}$$

$$s = 0.125(0.001 \text{ in.})$$

If observation No. 12 is omitted, $x = 6.26$, $x^2 = 3.6074$, and $n = 11$. Then $x_m = 0.570(0.001 \text{ in.})$ and $s = 0.068(0.001 \text{ in.})$

$$x_m = \frac{\Sigma x}{n} = \frac{4.71}{12}$$

$$x_m = 0.392(0.001 \text{ in.})$$

$$s = \sqrt{\frac{2.1347 - \frac{(4.71)^2}{12}}{12-1}}$$

$$s = 0.161(0.001 \text{ in.})$$

ular physical or chemical quantity, the theoretical distribution of repeated measurements will fall on the familiar "bell-shaped" or Gaussian distribution curve. The resulting data are said to be of "normal distribution." Data that do not accurately follow the theoretical distribution are said to be "skewed."

The Gaussian distribution is completely defined by two statistical quantities: 1. The arithmetic mean x_m which determines its x-axis position. 2. The standard deviation s which determines its exact shape.

The two treatments in the preceding cam-follower-wear problem would probably be compared on the basis of average wear. The average or arithmetic mean x_m is the best approximation of the true value being measured for normally distributed about the mean and is defined by

$$x_m = \frac{\Sigma x}{n} \tag{1}$$

where x is an individual observation, which in this case is depth of wear for a particular cam follower, and n is the number of observations. In this example, n corresponds to the number of cam followers undergoing each treatment, in this case 12.

Standard deviation, s, is a measure of scatter about the mean and is defined by

$$s = \sqrt{\frac{\Sigma(x - x_m)^2}{n-1}} \tag{2}$$

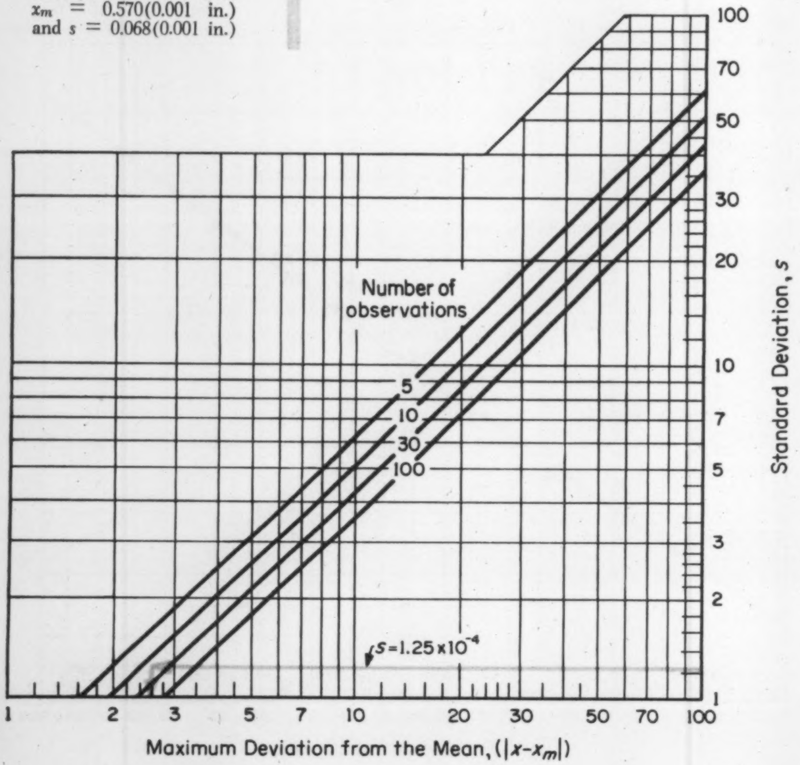


Fig. 4 — Left — Chart for rejecting false data, based on a system proposed by Chauvenet. With the standard deviation and number of observations known, the maximum allowable deviation from the mean can be found directly.

Fig. 5—Chart for finding the error of the arithmetic mean from its true value if the standard deviation and number of observations are known.

The factor $(n - 1)$ refers to the "degrees of freedom." The deviation of each individual observation from the mean is expressed as $x - x_m$. In the cam-follower problem, s is a numerical measure of the variation in wear observed for a given treatment. A more useful expression for the practical determination of s is:

$$s = \sqrt{\frac{\Sigma(x^2) - \frac{(\Sigma x)^2}{n}}{n-1}} \qquad (3)$$

Equation 3 is used to calculate standard deviation in Table 1.

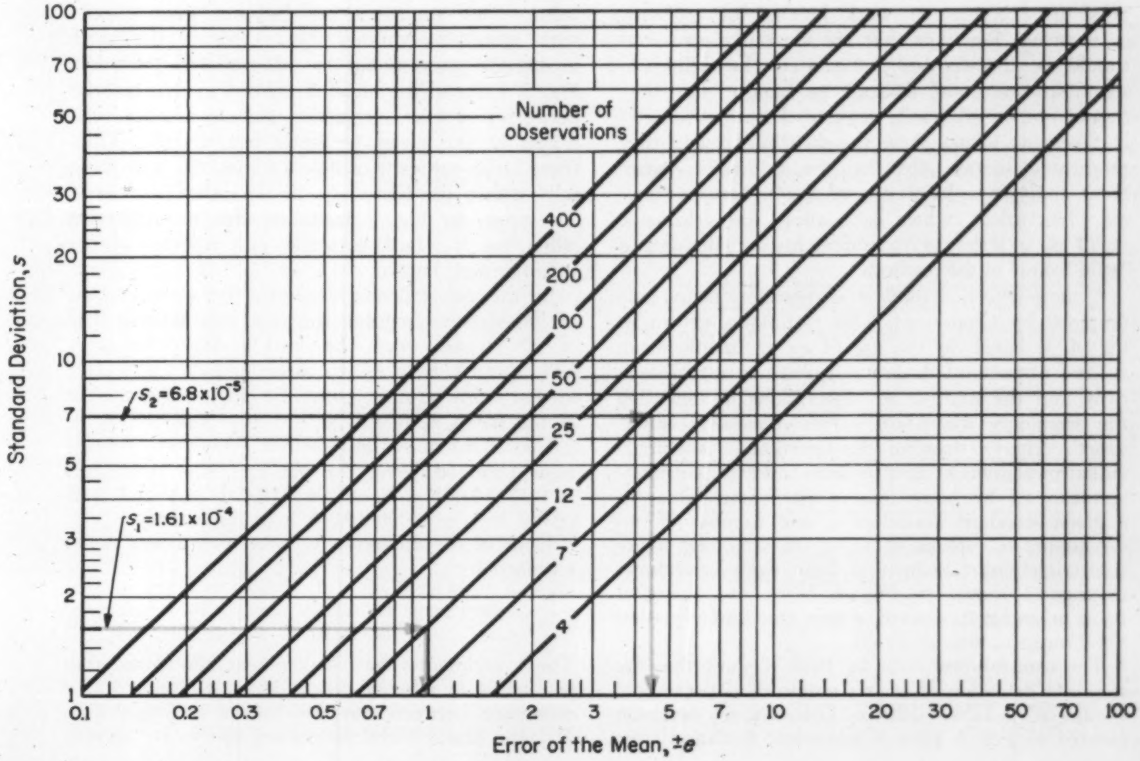
Variance, another statistical measure of variability in the determination of a numerical quantity, is the square of the standard deviation or s^2. The calculation of s and s^2 using Equation 3 is often simplified by taking an arbitrary zero and shifting all the numbers to a new scale. Thus, the numbers 83, 87, 89, and 91 can be written 0, 4, 6, and 8 for use in Equation 3. Variation about the mean is obviously identical for both series of numbers.

Although x_mx and s can be determined mathematically, as illustrated in Table 1, arithmetic probability paper, Fig. 2, often speeds the routine statistical analysis of data which follow a normal distribution. It also simplifies the interpretive process by providing a useful graphical means for data display.

Data following a normal statistical distribution appear as a straight line on arithmetic probability paper. Arithmetic mean x_m is the value of the ordinate at the intercept of the curve and the 50 per cent abscissa. Standard deviation s is the difference between the arithmetic mean x_m and the value of the ordinate at the 84 per cent abscissa, and it determines the slope of the curve. Only approximate values of x_m and s are obtained by this graphical method.

If the data do not fall on a straight line, a skewed distribution is indicated, and x_m and s must be calculated mathematically.

The arithmetic probability plot is often useful in detecting defects that might not ordinarily be discovered. Fig. 2 shows the distribution of actuation forces for a 25-piece sample of precision latch mechanisms. The latch must normally operate within a force tolerance of 7¾ grams ±2. Approximately 3 to 4 per cent of production latches were consistently being rejected because of too high or too low an actuation force. The curve in Fig. 2 is badly skewed for 10 to 15 per cent of the latches which have the highest actuation forces. On the basis of this apparent discrepancy in the distribution of forces, the individual latches in the 25-piece sample were dismantled. It was discovered that the high spring force in 3 of the 25 samples caused the cam



actuator to bind slightly against the side of the case. This accounted for the high rejection rate and the skewed distribution curve. Elimination of this defect and readjustment of the average spring force made the distribution fall along curve *B* and completely eliminated the problem.

The data are prepared for plotting on probability paper by first arranging the numbers in ascending numerical order. To facilitate the use of the curves included in this report, all data are written in exponential form using the same exponent throughout. After a suitable ordinate scale is selected and laid out, the first point of lowest numerical value is plotted on the $50/n$ per cent point on the abscissa. The difference, in cumulative per cent, between each plotted point is $100/n$ per cent. Therefore, if the data consist of 11 observations, such as shown in Fig. 3, the point representing the first observation number will be plotted on the $50/n$ or $50/11 = 4.5$ cumulative per cent abscissa. Distance between points measured along the abscissa is $100/n$ or $100/11 = 9.1$ cumulative per cent. Points will be plotted on the following abscissas: 4.5, 13.6, 22.7, 31.8, 40.9, 50.0, 59.1, 68.2, 77.3, 86.4, and 95.5. Tables are available for more rapid assessment of this information. In Fig. 3 is another arithmetic probability plot.

Rejection of False Data

Unreasonable observations are frequently encountered in experimental work because of accidents or mistakes. Readings that are obviously erroneous should be thrown out immediately. Doubtful observations are most difficult to handle, but they should not be arbitrarily rejected. Disproportionately divergent values skew the distribution and may produce a serious effect on the arithmetic mean. Some analysts prefer to discard the highest and lowest observations when calculating the arithmetic mean of a series of measurements to eliminate a "wild" value in the readings.

A more effective method of rejection is the one proposed by Chauvenet. This technique, shown in Fig. 4, is based on the use of an arithmetic mean x_m and a standard deviation s obtained mathematically and the number of observations n, including the seemingly discordant values. Basically, Chauvenet's criterion justifies the rejection of any individual measurement that deviates from the arithmetic mean x_m by more than a particular value for a given standard deviation, s, and number of observations, n. Values of $(x - x_m)$, n, and s are transcribed into exponential form, with a common exponent, for use in Fig. 4. With the divergent point or points in discard, a new standard deviation s and mean x_m are calculated.

The cam-follower data in Table 1 show that the standard deviation of wear s obtained with the "old treatment" is 1.25×10^{-4} in. This standard deviation entered in Fig. 4 gives a maximum deviation from the mean of 2.6×10^{-4}. Any individual value that deviates from the mean by more than this amount can be justifiably rejected according to Chauvenet's criterion. Observation No. 12 deviates from the mean by $9.3 \times 10^{-4} - 6.0 \times 10^{-4} = 3.3 \times 10^{-4}$ in. and can be rejected as erroneous. The mean x_m and standard deviation s are then recalculated, based on an 11-piece sample, Table 1.

Another method devised by the author for the rejection of one false observation from a series of measurements is applicable to data plotted on arithmetic probability paper. If one point on the graph appears to be disproportionately large or small so that a straight line cannot be fit to the data, the curve is plotted over, omitting the questionable observation. If the curve now falls on a reasonably straight line and the questionable point varies from the new mean by more than $2.3s$ for 5 to 10 observations, $2.5s$ for 10 to 30 observations, or $2.8s$ for 30 to 100 observations, the point is considered erroneous, and its rejection is justified in calculating the arithmetic mean. If a straight-line relationship cannot be obtained, the mathematical approach must be used. If observed values are rejected on the basis of any criterion, it should be so stated in the report describing the experiment.

Error of the Mean

The value of arithmetic mean obtained from a series of measurements only approximates the true value. The approximation becomes more precise with more observations. Also, error of the mean is directly proportional to the standard deviation, Fig. 5. Error of the mean is defined as that interval between $-e$ and $+e$, which includes chance variations in the mean 95 times out of 100. Thus, there is 95 per cent confidence that the true mean falls within the limits $\pm e$ of the calculated mean. The chart in Fig. 5 facilitates this determination when the standard deviation and number of observations are known.

In the cam-follower example, the average wear of followers undergoing the new treatment is 3.92×10^{-4} inches. From the chart in Fig. 5 for $s_1 = 1.61 \times 10^{-4}$, error of the mean e_1 is $\pm 1.0 \times 10^{-4}$ in. For followers undergoing the old treatment, error of the mean e_2 is 4.5×10^{-5} in., based on $s_2 = 6.8 \times 10^{-5}$ and 11 observations. Therefore, average wear obtained using the old and new treatments is 0.57 (0.001 in.) ±0.045 (0.001 in.) and 0.39 (0.001 in.) ± 0.090 (0.001 in.), respectively.

Error of the difference between two means is determined by

$$E_m = \sqrt{e_1^2 + e_2^2} \qquad (4)$$

The experimenter has 95 per cent confidence that one mean is actually greater than the other if the difference between the two means is larger than E_m. The experimental results are said to be "significant" if the measured value exceeds the error at the confidence level chosen. Applied to the cam follower problem,

$$E_m = \sqrt{(1.0 \times 10^{-4})^2 + (4.5 \times 10^{-5})^2}$$

$$= 0.000105 \text{ in.}$$

Experimental difference between the two means was $5.7 \times 10^{-4} - 3.92 \times 10^{-4} = 1.78 \times 10^{-4}$ in. Since the error E_m is considerably less than this value, the investigator has better than 95 per cent confidence that the new heat-treating method produces significantly improved results over the old method. If the experimental difference between the two means had been less than 0.000105 in., any improvement offered by the new technique would be questionable. The test would have to be repeated using larger sample sizes to detect a significant difference, assuming such a difference exists. As Fig. 5 shows, to decrease the error by one-half, the sample sizes would have to be increased by a factor of 4, a most inefficient process.

Part 2—Multiple-Factor Experiments

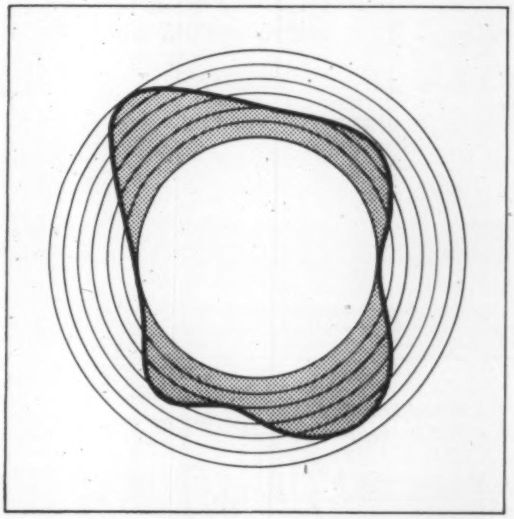
This first article of a two-part series has covered simple one-factor experiments at two levels replicated *n* times. For example, two heat-treating methods were compared under the same test conditions.

If the two treatments were evaluated on two different test machines, the resulting experiment would be evaluated as a two-factor experiment each at two levels. If three heat-treating techniques were compared on two machines under two different test conditions, the experiment is a three-factor experiment each at two levels. These multiple-factor experiments will be discussed in Part 2 which will be published in the June 25 issue of MACHINE DESIGN.

Tips and Techniques

Area Approximations

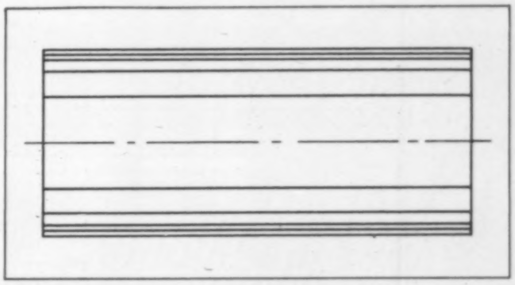
Irregular-area approximations are often simplified by a method which uses "curved squares." First, select the approximate center of the area and draw the largest possible circle which will lie entirely within the area. Then, increase the radius in equal increments and draw circles at each radius. The largest circle drawn is that which will totally include the area.



The approximation of the area is the area of the totally included circle, plus the sum of the areas of the partial rings which are bounded by the concentric circles and the edges of the area being approximated. The area of each partial ring is obtained by measuring the inner and outer partial circumferences, averaging these values, and multiplying the average by the difference in radii between the inner and outer ring surfaces.—JESSE ROTH, *Milwaukee, Wis.*

Shading Curved Surfaces

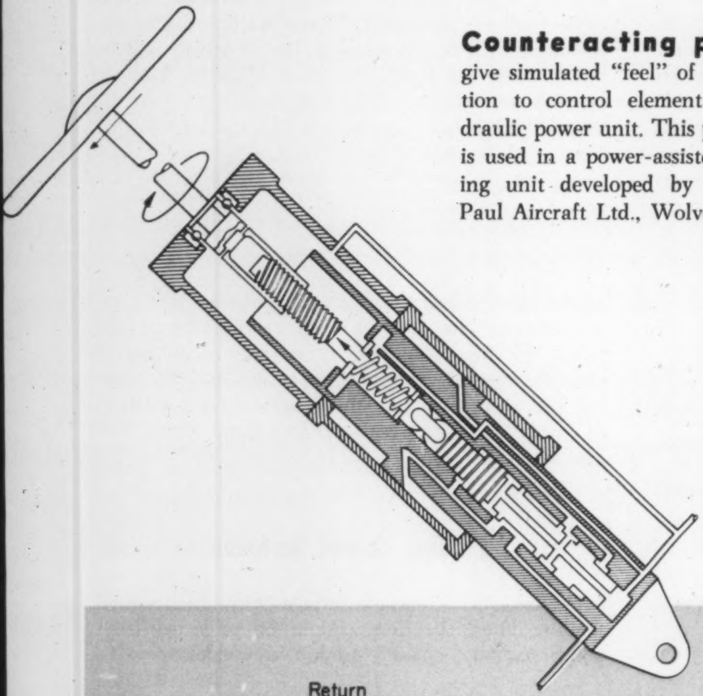
To indicate a curved surface with longitudinal shading lines, the lines should be projected from points equally spaced around a semicircle. To quickly obtain the approximate effect, continuously divide the shaft diameter in half and draw lines through the center of each consecutive space.—W. H. SHEPPARD, *Malton, Ontario, Canada.*

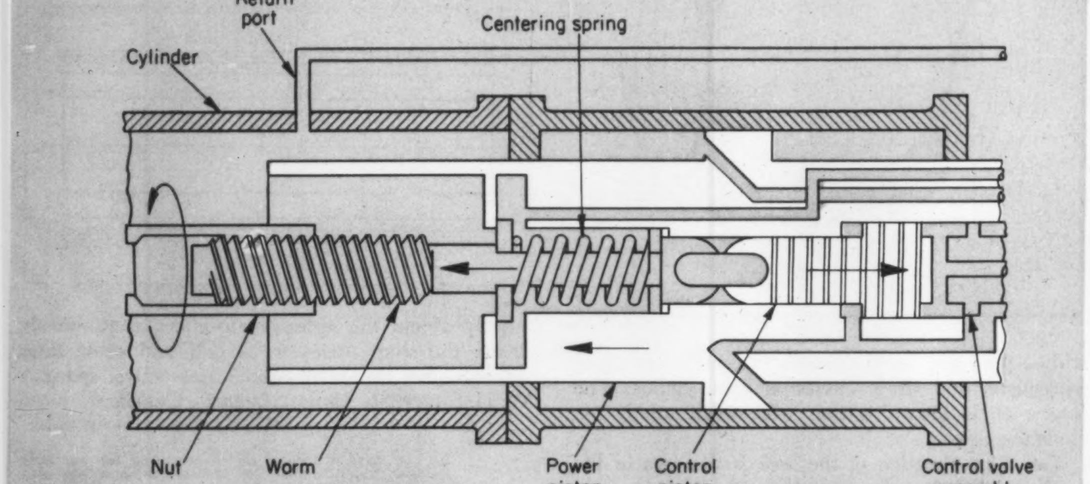


Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

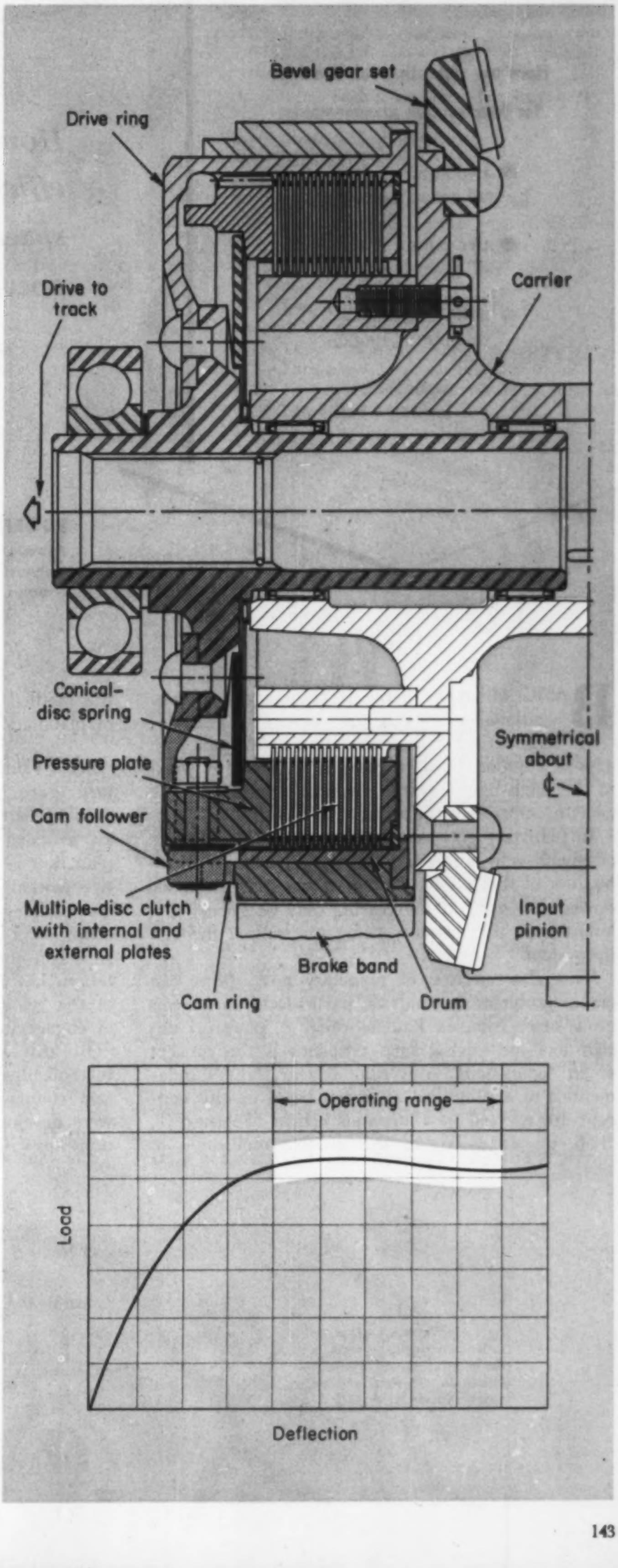
scanning the field for *ideas*

Counteracting pistons give simulated "feel" of load action to control element in hydraulic power unit. This principle is used in a power-assisted steering unit developed by Boulton Paul Aircraft Ltd., Wolverhampton, England. When movement is imparted to steering wheel and fluid is supplied to one side of a hydraulic power-piston, pressure is also applied to the corresponding end of a control piston to produce a reaction in a direction opposite to control-piston motion. This reaction is transmitted back through a worm and nut assembly and is "felt" by the operator as a centering force on the steering wheel. Effective area of control piston is 20 per cent of power-piston end area, and the same percentage of road wheel load is felt by the operator through the wheel.




Return port
Centering spring
Cylinder
Nut
Worm
Power piston
Control piston
Control valve assembly

Constant-force spring action provided by conical-disc spring compensates for wear in operating assembly. As employed in the Spot-Turn transmission developed by Oliver Corp. for a crawler tractor, the spring operates in the relatively flat portion of its load-deflection curve holding the pressure plate against a multiple disc clutch. Changes in deflection due to wear in clutch element do not alter the force developed by the spring. The design provides a compact assembly with high force capacity, replacing a conventional multiple coil-spring arrangement.


Bevel gear set
Drive ring
Carrier
Drive to track
Conical-disc spring
Pressure plate
Cam follower
Symmetrical about ℄
Multiple-disc clutch with internal and external plates
Input pinion
Brake band
Cam ring
Drum
Operating range
Load
Deflection

Here are operating relationships for four system arrangements:

- two input shafts—all gears in motion
- two output shafts—all gears in motion
- one input shaft—differential motion
- one input shaft—self-locking conditions

How to find efficiency, speed, and power in . . .

PLANETARY

EUGENE I. RADZIMOVSKY
Associate Professor of Mechanical Engineering
University of Illinois
Urbana, Ill.

BASIC difference between planetary and conventional gearing is the velocity of gear engagement. For the conventional gear pair with axes of rotation fixed, engagement velocity is equal to the pitch-line velocity. Power transmitted by the gears never exceeds the input.

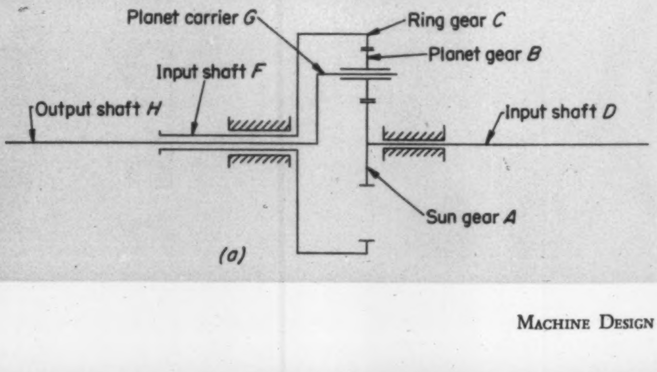
In planetary gear arrangements, however, velocity of engagement is not equal to the pitch-line velocity because of the relative motion of the gear members. Power developed in the gearing may be greatly different from that actually being transmitted through the system.

This characteristic of planetary gear trains can create problems in analysis, particularly as systems grow more complex kinematically. A powerful design tool for solving such problems is the concept of an "equivalent" conventional gear train. Fundamentals of a simplified approach based on this concept are covered in a previous article (February 8, 1956, pp. 101-110). In this article, application of the method to analysis of more advanced systems of planetary gearing will be demonstrated.

Basic Concepts: Source of relative motion in planetary gearing is the planet cage which carries the planet gears. In the equivalent system approach, an artificial velocity is imposed on the complete planetary gear train to "stop" the planet cage. Relative motions of all members of the planetary train are unchanged. However, the planet gears now become idlers and the entire train may be considered as a conventional gear train with fixed axes of rotation. Only change is in the pitch-line velocities of the gears; they are now equal to the velocities of engagement of the gears in the planetary train.

By this approach, efficiency, speed, and power relationships for simple planetary trains and certain compound arrangements with one fixed gear were developed in the previous article. These relationships will be assumed here.

Fig. 1—Planetary gear train with two input shafts and one output shaft. Basic system is shown at *a* and component trains at *b* and *c*.



GEAR DRIVES

Nomenclature

e_t = Overall efficiency of planetary gear system
e_t', e_t'' = Efficiencies of component planetary gear trains
L', L'' = Tooth-mesh power losses in component gear trains
L_t = Total tooth-mesh power loss in planetary gear system
m_p = Speed ratio of planetary gear train
N = Number of teeth in gear
P = Power, ft-lb per sec
P', P'' = Component powers, ft-lb per sec
P_i, P_o = Input and output power, respectively, ft-lb per sec
R = Planetary velocity ratio
= v_e/v
T = Torque, lb-ft
v = Pitch-line velocity of gear pair, fps
v_e = Velocity of engagement of gear pair, fps
η', η'' = Efficiencies of conventional gear trains
η_t = Overall efficiency of conventional gear system
ω = Angular velocity, rpm
ω', ω'' = Component angular velocities, rpm

Another concept is also useful in the analysis of planetary gearing. In general, the power on a rotating shaft is proportional to the product of the torque acting on this shaft and its angular velocity. If the power is made up of two components produced at equal torque, ratio of these power components equals the ratio of the corresponding shaft velocities.

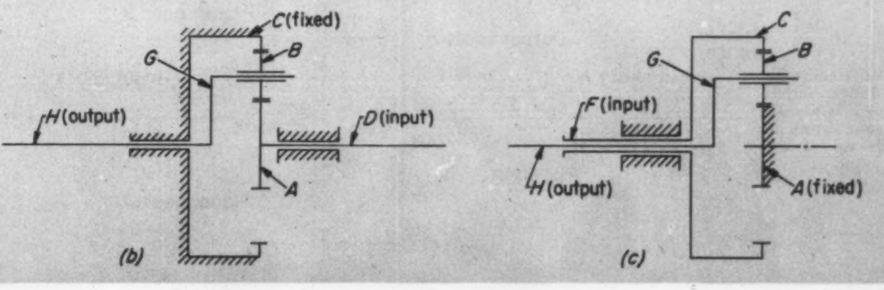
Two Input Shafts: Consider the planetary train depicted schematically in Fig. 1*a*. Ring gear *C* is connected rigidly to hollow shaft *F*. Planet carrier *G*, which carries planet gear *B*, is connected rigidly to shaft *H* and sun gear *A* is connected to shaft *D*.

Each shaft in this gear train may be either a driving or a driven member, depending on the relationship between shaft rotation and torque. If the external torque applied to the shaft acts in the direction of shaft rotation, the shaft is a driver. If the direction of torque action is opposite to that of shaft rotation, the shaft is a driven member.

Fig. 2 illustrates this rule. Power is transmitted from the prime mover to the driven machine by a transmission. Shaft *D* is the driving (input) shaft for the transmission, while shaft *H* is the driven (output) shaft. Assume shaft *D* rotates in the positive direction. Angular velocity ω_D is positive and external torque T_D on this shaft must be positive also. However, if shaft *H* rotates in the positive direction, resistance of the driven machine will produce a torque acting in a direction opposite to that of shaft rotation.

Assume now that the direction of the prime mover is reversed. Then ω_D, T_D, and ω_H become negative, while the resisting torque on driven shaft *H* must be positive. These relationships lead to a simple rule. The product of external torque and angular velocity is always positive for the driver and always negative for the driven member.

In a conventional gear train, driving and driven



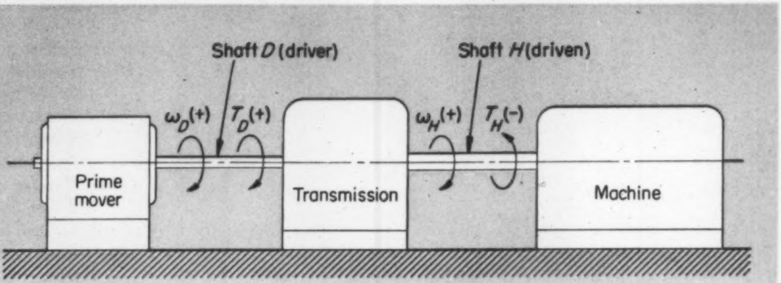


Fig. 2—Velocity-torque relationships at driving and driven shafts of a gear transmission. Product of external torque and angular velocity is always positive for a driving member and always negative for a driven member.

members are easily identified. However, the same does not always hold true for planetary gear trains. Sometimes, the driving members must be considered as driven members, or vice-versa, when power losses in the system and train efficiency are analyzed.

In the planetary train, Fig. 1*a*, assume that shafts *D* and *F* are the driving members and rotate in the positive direction. Thus, external torques acting on these shafts are positive. Shaft *H* becomes the driven member.

Basic velocity relationship for this train is

$$\omega_H = \omega_G = \frac{\omega_A N_A + \omega_C N_C}{N_A + N_C} \tag{1}$$

where symbols are defined in *Nomenclature* and subscripts identify individual train elements.

Based on Equation 1, angular velocity ω_H is positive when ω_A and ω_C are positive, as assumed. Thus, since shaft *H* is the driven member, external torque T_H acting on this shaft is negative.

Angular velocity ω_H has two components: ω_H' and ω_H''. Component ω_H' is that portion of the angular velocity of shaft *H* contributed by the motion of sun gear *A* alone (gear *C* stationary). It is positive when ω_A is positive.

The other velocity component, ω_H'', represents the angular velocity contributed by the motion of gear *C* alone (gear *A* stationary). It is positive when ω_C is positive.

Power P_o delivered to the driven shaft may be also considered as having two components: P_o' from gear *A* and P_o'' from gear *C*. In fact, the complete planetary system, Fig. 1*a*, can be regarded as an assembly of two component planetary trains. Each of these trains has its own efficiency.

In one component train, Fig. 1*b*, gear *C* is fixed, gear *A* is the driver, and planet carrier *G* is the driven member. Speed ratio m_p' of this train is

$$m_p' = \frac{\omega_A}{\omega_H'} = 1 + \frac{N_C}{N_A} \tag{2}$$

Efficiency e_t' of this type of planetary train is given by

$$e_t' = 1 - R'(1 - \eta') = 1 - \left(\frac{N_C}{N_A + N_C}\right)(1 - \eta') \tag{3}$$

Input power P_i' at driving shaft *D* in this train is

$$P_i' = \frac{P_o'}{e_t'} \tag{4}$$

For the other component train, Fig. 1c, speed ratio, efficiency, and input power (driving shaft *F*) are

$$m_p'' = \frac{\omega_C}{\omega_H''} = 1 + \frac{N_A}{N_C} \tag{5}$$

$$e_t'' = 1 - R''(1 - \eta'') = 1 - \left(\frac{N_A}{N_A + N_C}\right)(1 - \eta'') \tag{6}$$

$$P_i'' = \frac{P_o''}{e_t''} \tag{7}$$

Efficiency e_t of the complete system, Fig. 1*a*, is

$$e_t = \frac{P_o}{P_i} = \frac{P_o' + P_o''}{P_i' + P_i''} = \frac{P_o}{\dfrac{P_o'}{e_t'} + \dfrac{P_o''}{e_t''}} \tag{8}$$

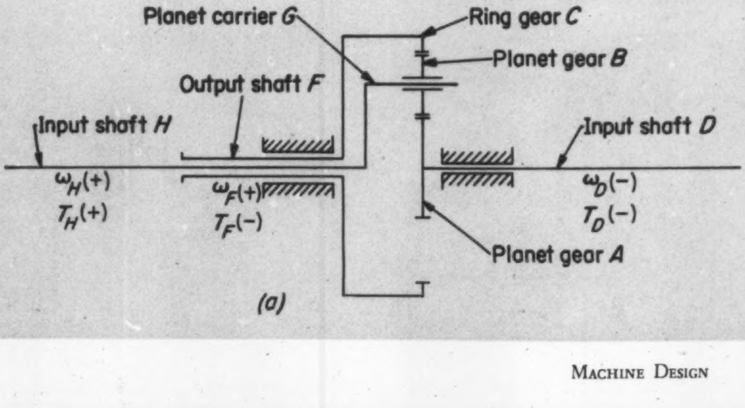


Fig. 3—Planetary gear train with two input shafts and one output shaft. Basic system at *a* is a variation of the arrangement shown in Fig. 1*a* and is made up of the component trains at *b* and *c*.

Before this equation can be used, relationship between P_o' and P_o'' or P_i' and P_i'' must be established. By definition, $P_o = P_o' + P_o''$. Also, P_o' and P_o'' are proportional to component velocities ω_H' and ω_H'', respectively. From these relationships and Equations 2 and 5, the following expressions can be readily derived:

$$P_o' = \frac{P_o}{1 + \dfrac{\omega_C N_C}{\omega_A N_A}} \tag{9}$$

$$P_o'' = \frac{P_o}{1 + \dfrac{\omega_A N_A}{\omega_C N_C}} \tag{10}$$

Combining Equations 8, 9, and 10 and simplifying gives

$$e_t = \frac{\omega_A N_A + \omega_C N_C}{\dfrac{\omega_A N_A}{e_t'} + \dfrac{\omega_C N_C}{e_t''}} \tag{11}$$

Thus, efficiency of the complete planetary gear system, Fig. 1*a*, is a function of the number of teeth in gear *A* and in gear *C*, the angular velocities of driving shafts *D* and *F*, and the individual efficiencies of the component planetary trains, Fig. 1*b* and c. The component train efficiencies, in turn, depend on the number of teeth in each train gear and the efficiency of each gear mesh.

Modified Train Arrangement: A variation of the previous planetary system is shown in Fig. 3*a*. Here, the general arrangement of system elements is the same as before, but shafts *H* and *D* are now the input members, and shaft *F* is the output member. This system also can be considered as made up of two component trains.

One component train, Fig. 3*b*, has the basic planetary arrangement with the planet carrier stationary. Power flows from sun gear *A*, the driving member, to ring gear *C*, the driven member. Planet gear *B* is an idler. Train efficiency e_t', which is the same as efficiency η' of its conventional-gear counterpart, is merely the product of the efficiencies of gear pairs *A-B* and *B-C*.

In the other component train, Fig. 3c, ring gear *C* and planet carrier *G* are free to rotate. Sun gear *A* is the stationary member. Efficiency e_t'' of this train is

$$e_t'' = \frac{\eta''}{\eta'' + R''(1 - \eta'')} \tag{12}$$

where $R'' = N_A/(N_A + N_C)$.

From Equation 1, angular velocity of ring gear C on driven shaft *F*, Fig. 3*a*, is

$$\omega_C = \omega_F = \omega_H \frac{N_A + N_C}{N_C} - \omega_A \frac{N_A}{N_C} \tag{13}$$

If shafts *H* and *D* (gear *A*) are input members, Equation 13 shows that these shafts must rotate in opposite directions to impart the same direction of rotation to shaft *F*. When angular velocity of shaft *H* is assumed to be positive, angular velocity of shaft *D* must be negative, and shaft *F* rotates in the positive direction. Accordingly, external torque T_F is negative, torque T_H is positive, and torque T_D is negative.

Output power P_o delivered at shaft *F* has two components: P_o' from one component train, Fig. 3*b*, and P_o'' from the other component train, Fig. 3c. Power-efficiency relationships for the component trains and the complete system have the same form as those for the system previously analyzed. Input power at shaft *D* is given by Equation 4 and at shaft *H* by Equation 7. Efficiency of the complete system is expressed by Equation 8.

As in the previous analysis, expressions for P_o' and P_o'' can be developed for use with Equation 8:

$$P_o' = \frac{P_o}{1 - \dfrac{\omega_H (N_A + N_C)}{\omega_H N_A}} \tag{14}$$

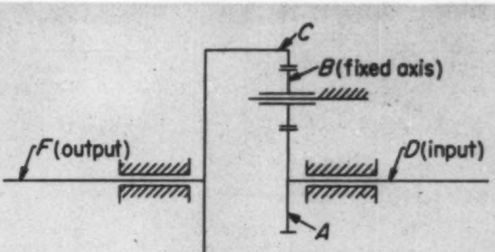
$$P_o'' = \frac{P_o}{1 - \dfrac{\omega_A N_A}{\omega_H (N_A + N_C)}} \tag{15}$$

Combining Equations 8, 14, and 15 and simplifying gives

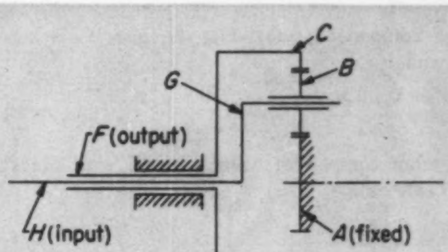
$$e_t = \frac{\omega_H (N_A + N_C) - \omega_A N_A}{\dfrac{\omega_H (N_A + N_C)}{e_t''} - \dfrac{\omega_A N_A}{e_t'}} \tag{16}$$

In this equation, e_t'' will have a negative value when ω_H is positive.

Another variation of this form of planetary sys-



(*b*)



(*c*)

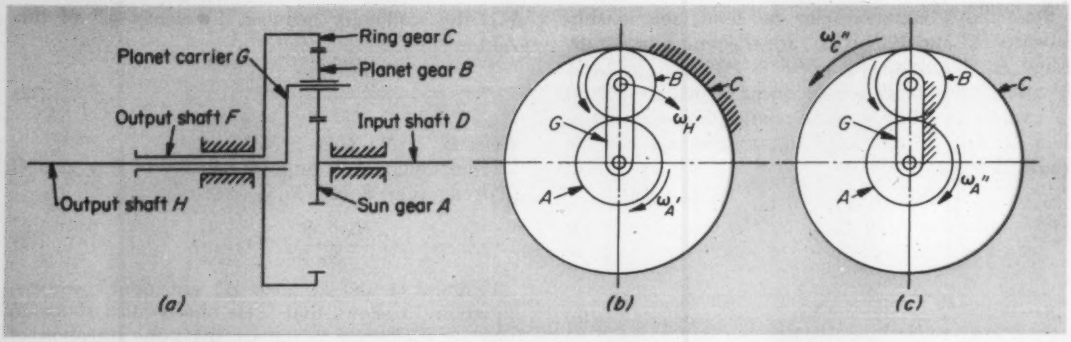

Ring gear C
Planet carrier G
Planet gear B
Output shaft F
Input shaft D
Output shaft H
Sun gear A
(a)
B
C
G
ω_H'
A
ω_A'
(b)
ω_C''
B
C
G
A
ω_A''
(c)

Fig. 4—Planetary gear train with two output shafts and one input shaft. Basic system is shown at *a* and component trains at *b* and *c*.

tem, Figs. 1*a* and 3*a*, is obtained when shafts *H* and *F* are the driving members and shaft *D* is the driven member. Here, system efficiency is

$$e_t = \frac{\omega_H (N_A + N_C) - \omega_C N_C}{\dfrac{\omega_H (N_A + N_C)}{e_t''} - \dfrac{\omega_C N_C}{e_t'}} \tag{17}$$

In one component train of this system, shaft *H* is stationary and planet gear *B* functions as an idler. Train efficiency $e_t' = \eta'$ which is the product of the efficiencies of gear pairs *C*-*B* and *B*-*A*.

For the other component train in which shaft *F* is held stationary, efficiency e_t'' is

$$e_t'' = \frac{\eta''}{\eta'' + (1 - \eta'') \dfrac{N_C}{N_A + N_C}} \tag{18}$$

where $\eta'' = \eta'$.

Two Output Shafts: The previous approach can also be used to determine the efficiency of planetary systems having the same general arrangement as before but with one driving shaft and two driven shafts. Such a system is shown in Fig. 4*a*. Shaft *D* is the input shaft and shafts *F* and *H* are output shafts.

Here again, two component planetary trains can be identified, Fig. 4*b* and *c*.

From Equation 1,

$$\omega_A = \omega_D = \omega_H \frac{N_A + N_C}{N_A} - \omega_C \frac{N_C}{N_A} \tag{19}$$

For one component train, Fig. 4*b*, gear *C* is stationary and

$$\omega_A' \doteq \omega_H \frac{N_A + N_C}{N_A} \tag{20}$$

In the other component train, Fig. 4c, with planet carrier *G* stationary,

$$\omega_A'' = - \omega_C \frac{N_C}{N_A} \tag{21}$$

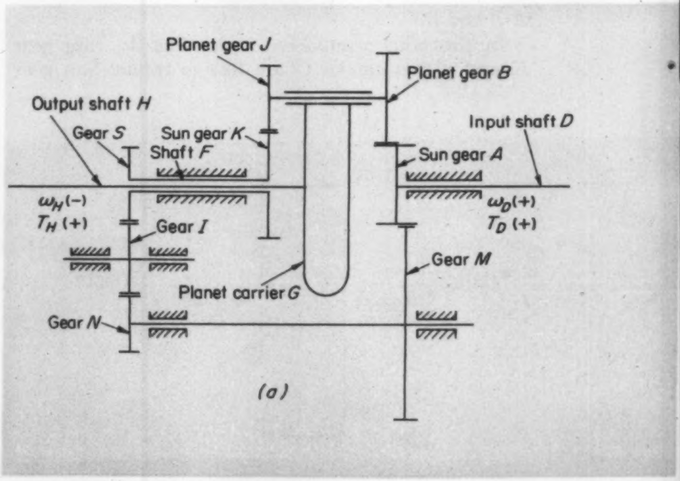
Based on Equation 19 and the conditions of power transmission for this planetary system, Fig. 4*a*, shaft *H* must rotate in the same direction as gear *A* while shaft *F* must rotate in the opposite direction. Assume gear *A* rotates in the positive direction. Then, external torque at driving shaft *D* is positive. Since driven shaft *H* (planet carrier *G*) also rotates in the positive direction, external torque acting on this shaft must be negative. For shaft *F* (ring gear *C*), which rotates in a negative direction, external torque is positive.

Input power P_i for the system has two components: P_i' which is transmitted to the planet carrier through one component train, Fig. 4*b*, and P_i'' which is transmitted to shaft *F* through the other component train, Fig. 4c. These power components, which are proportional to the corresponding angular velocities, ω_A' and ω_A'', can be determined from

$$P_i' = \frac{P_i}{1 + \dfrac{- \omega_C N_C}{\omega_H (N_A + N_C)}} \tag{22}$$

$$P_i'' = \frac{P_i}{1 + \dfrac{\omega_H (N_A + N_C)}{- \omega_C N_C}} \tag{23}$$

Efficiency of the complete planetary system is


Planet gear J
Planet gear B
Output shaft H
Input shaft D
Gear S
Sun gear K
Shaft F
Sun gear A
$\omega_H(-)$
$T_H(+)$
$\omega_D(+)$
$T_D(+)$
Gear I
Gear M
Planet carrier G
Gear N
(a)

$$e_t = \frac{P_o' + P_o''}{P_i} = \frac{P_i' e_t' + P_i'' e_t''}{P_i} \tag{24}$$

Combining Equations 22, 23, and 24 and simplifying gives

$$e_t = \frac{e_t' \omega_H (N_A + N_C) - e_t'' \omega_C N_C}{\omega_H (N_A + N_C) - \omega_C N_C} \tag{25}$$

where e_t' and e_t'' are the efficiencies of the planetary component trains in Fig. 4*b* and c, respectively. Efficiency e_t' can be determined from Equation 3 and $e_t'' = \eta''$.

Other variations of this form of planetary system can be analyzed by the same general procedure.

Planetary Differential: Consider now the differential planetary gear system depicted schematically in Fig. 5*a*. Input shaft *D* is connected directly to sun gear *A* which is engaged with both planet gear *B* and gear *M*.

Motion of shaft *D* is transmitted to hollow shaft *F* and sun gear *K* through gears *A*, *M*, *N*, *I*, and *S* to maintain a constant speed ratio between gears *A* and *K*. Output shaft *H* is connected to planet carrier G.

Assume that input shaft *D* rotates in the positive direction. Then, angular velocity ω_D and the external torque acting on this shaft are positive.

This planetary system may be considered as an assembly of two component planetary trains and a conventional gear transmission which consists of gears *A*, *M*, *N*, *I*, and *S*. One component train, Fig. 5*b*, has gear *A* as the driving member, gear *K* as the fixed member, and planet carrier *G* as the driven member. In the other component train, Fig. 5c, gear *K* is the driver while gear *A* is fixed.

Speed ratio m_p' of the first component train, Fig. 5*b*, is

$$m_p' = \frac{\omega_A}{\omega_H'} = \frac{N_A N_J - N_B N_K}{N_A N_J} = - \frac{N_B N_K - N_A N_J}{N_A N_J} \quad \ldots\ldots(26)$$

Assume $N_A N_J < N_B N_K$. Speed ratio m_p' becomes negative and angular velocity of driven shaft *H* in this component train is

$$\omega_H' = \frac{\omega_A}{m_p'} = - \omega_A \frac{N_A N_J}{N_B N_K - N_A N_J} \tag{27}$$

Speed ratio m_p'' of the other component train, Fig. 5c, is

$$m_p'' = \frac{\omega_K}{\omega_H''} = \frac{N_B N_K - N_A N_J}{N_B N_K} \tag{28}$$

For the assumed condition, m_p'' is positive.

Relationship between angular velocities ω_K and ω_A, Fig. 5*a*, can be expressed as

$$\omega_K = - \omega_A \frac{N_A N_N}{N_M N_S} \tag{29}$$

Therefore, angular velocity of shaft *H* in the second component planetary train, Fig. 5c, is

$$\omega_H'' = \frac{\omega_K}{m_p''} = - \omega_A \frac{N_A N_N N_B N_K}{N_M N_S (N_B N_K - N_A N_J)} \tag{30}$$

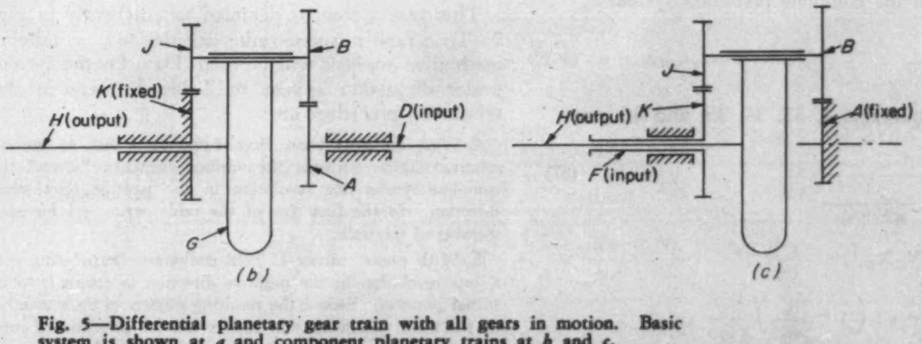
Total angular velocity of driven shaft *H* in the planetary system, Fig. 5*a*, is

$$\omega_H = \omega_H' + \omega_H'' = - \omega_A \left[\frac{N_A N_J}{N_B N_K - N_A N_J} + \frac{N_A N_N N_B N_K}{N_M N_S (N_B N_K - N_A N_J)} \right] \tag{31}$$

Value of ω_H is negative for the assumed condition, $N_A N_J < N_B N_K$.

Thus, external torque acting on output shaft *H* must be positive. Total output power P_o delivered at this shaft is $P_o = P_i / e_t$.

This power consists of two components: P_o' from the first component train, Fig. 5*b*, and P_o'' from the second component planetary train, Fig. 5c, and the conventional train made up of gears *A*, *M*, *N*, *I*, and S. These power components are proportional to the corresponding angular velocities, ω_H' and ω_H''. In-



(*b*) (*c*)

Fig. 5—Differential planetary gear train with all gears in motion. Basic system is shown at *a* and component planetary trains at *b* and *c*.

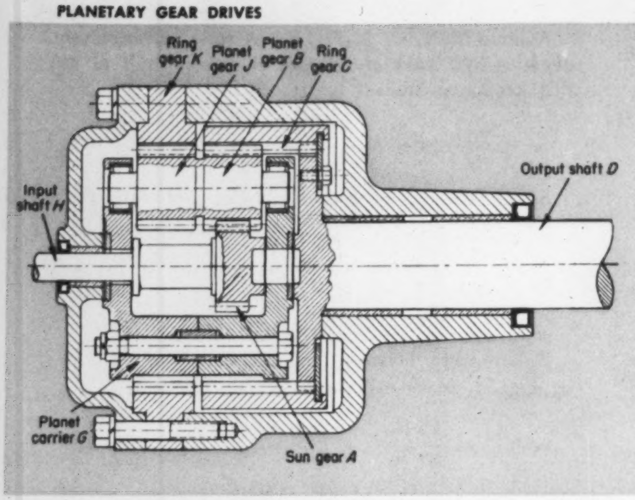


Fig. 6—Differential planetary gear reducer which provides a large speed ratio with a limited number of gears in a compact train arrangement.

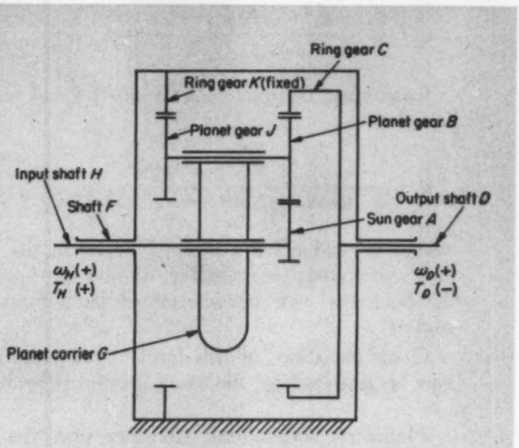


Fig. 7—Schematic arrangement of system elements for differential planetary gear reducer shown in Fig. 6. Train analysis is given in Table 1.

troducing Equations 27 and 30 in this proportional relationship and simplifying gives

$$\frac{P_o'}{P_o''} = \frac{\omega_H'}{\omega_H''} = \frac{N_J\, N_M\, N_B}{N_N\, N_B\, N_K} = Q \tag{32}$$

where Q is a constant for a given gear train.

Solving for P_o' *and* P_o'' in terms of P_o yields

$$P_o' = P_o \frac{Q}{1 + Q} \tag{33}$$

$$P_o'' = P_o \frac{1}{1 + Q} \tag{34}$$

Power P_i' at input shaft of the first component train, Fig. 5*b*, can be determined from Equation 4. For the second component train, Fig. 5*c*,

$$P_i'' = \frac{P_o''}{e_t''\, e_w} \tag{35}$$

where e_w = efficiency of conventional gear transmission consisting of gears *A*, *M*, *N*, *I*, and *S*.

Efficiency of the complete planetary system is

$$e_t = \frac{P_o}{P_i' + P_i''} \tag{36}$$

Combining Equations 4, 33, 34, 35, and 36 gives

$$e_t = \frac{1 + Q}{\dfrac{Q}{e_t'} + \dfrac{1}{e_t'' + e_w}} \tag{37}$$

For $N_A N_J < N_B N_K$,

$$\begin{aligned} e_t' &= 1 - (1 - \eta')\left(1 - \frac{1}{m_p'}\right) \\ &= 1 - (1 - \eta')\,\frac{N_B\, N_K}{N_B\, N_K - N_A\, N_J} \end{aligned} \tag{38}$$

$$\begin{aligned} e_t'' &= \frac{\eta'' - (1 - \eta'')\left(\dfrac{1}{m_p''} - 1\right)}{\eta''} \\ &= \frac{\eta'' - (1 - \eta'')\left(\dfrac{N_A\, N_J}{N_B\, N_K - N_A\, N_J}\right)}{\eta''} \end{aligned} \tag{39}$$

where $\eta' = \eta''$.

Self-Locking Differential System: The planetary reducer shown in Fig. 6 was designed to operate for relatively short periods. It provides a large speed ratio using a limited number of gears. Power is transmitted from shaft *H* to shaft *D*. When no torque is applied to driving shaft *H*, the entire drive is supposed to work as a self-locking mechanism to prevent power flow in the reverse direction; that is, from driven shaft *D* to driving shaft *H*.

In addition to drive efficiency, the conditions that make this gear system self-locking should be analyzed. The reducer, Fig. 6, has the following specifications: ω_H = 400 rpm, $N_A = 13$, $N_B = 13$, $N_J = 13$, $N_C = 41$, and $N_K = 40$.

This gear system is depicted schematically in Fig. 7. To simplify speed-ratio calculations, a tabular method of analysis will be used. Data for the system under discussion appear in Table 1. Steps in the tabulation procedure are:

1. With the gear train "locked-up" as a unit to prevent relative motion between the various elements, "rotate" the complete system one revolution in the positive (clockwise) direction. In the first line of the table, write +1 for each member of the train.
2. With planet carrier *G* held stationary, "turn" ring gear *K* one revolution in the negative direction to return it to its initial position. Record the resulting motion of each member of the train, following sign convention for direction of rotation, in the second line of the table. These data represent motions relative to the planet carrier which remains stationary during this operation.

3. Add the values on the first and second lines of the table for each member and write the totals in the third line.

From the data in Table 1, speed ratios for the system as a whole and between different train elements can be readily determined.

For the complete system, Fig. 7,

$$m_p = \frac{\omega_H}{\omega_D} = \frac{\omega_A}{\omega_C} = \frac{1 + \dfrac{N_K}{N_A}}{1 - \dfrac{N_K}{N_C}} = \frac{N_C(N_A + N_K)}{N_A(N_C - N_K)} \qquad (40)$$

Substituting values for the reducer unit, Fig. 6, gives $m_p = +167.15$.

Speed ratio m_p' between driving shaft H and planet carrier G is

$$m_p' = \frac{\omega_A}{\omega_G} = \frac{N_A + N_K}{N_A} \qquad (41)$$

For the reducer unit, $m_p' = +4.077$.

Speed ratio m_p'' between planet carrier G and driven shaft D is

$$m_p'' = \frac{\omega_G}{\omega_C} = \frac{N_C}{N_C - N_K} \qquad (42)$$

For the reducer unit, $m_p'' = +41$. Speed ratio of the system, $m_p = m_p' \, (m_p'') = 4.077(41) = +167.15$ which checks the previous calculation.

Speed of driven shaft D in the reducer is 400/167.15 = 2.392 rpm. Speed of planet carrier G is 400/4.077 = 98.11 rpm. Since speed ratio m_p is positive, the driven and driving shafts rotate in the same direction. Therefore, external torque T_H acting on the driver is positive, while external torque T_D at the driven shaft is negative, Fig. 7.

Based on the equivalent system concept discussed previously, an equivalent gear train can be obtained by adding to the entire system an additional angular velocity $(-\omega_G)$, which is equal to the angular velocity of the planet carrier, but opposite in direction. Relative motions of the members of the planetary train will not be influenced by this operation.

To meet this condition in the planetary reducer unit, a velocity of −98.11 rpm must be added to the system. Angular velocities of the individual elements in the equivalent gear train are: Shaft D', −95.72 rpm; shaft H', 301.9 rpm; planet gear B', −301.9 rpm; planet gear J', −301.9 rpm; ring gear K', −98.11 rpm.

This equivalent train is shown schematically in Fig. 8. External torques T_D' and T_H' acting on shafts D' and H' of the equivalent train are the same as those acting on shafts D and H in the actual planetary system. Thus, torque T_D' is negative while T_H' is positive. Product of torque and velocity for shaft H' is positive; therefore, this shaft is a driver in the equivalent train. Product of torque and velocity at shaft D' is also positive; therefore, this shaft is a driver in the equivalent train. Ring gear K', which is connected to the hollow shaft F', becomes the driven member in this train. Thus, the equivalent gear train, Fig. 8, has two input shafts, H' and D', and one output shaft, F'.

The entire equivalent train can be considered as made up of two component trains. One component train transmits power from shaft H' through gears A', B', J', and K' to the driven member, which here is the ring gear K'. The other component train transmits power from shaft D' to the same driven member, gear K', by means of gears C', B', J', and K'.

To determine system losses, the power developed at the two driving members must first be established. In the actual system, output power P_o at the driven shaft D is

$$P_o = P_i \, e_t \qquad (43)$$

where P_i = input power at driving shaft H.

Power P_A' at gear A' in the first equivalent component train is

$$P_A' = P_i \, R' \qquad (44)$$

where R' = planetary velocity ratio for the first component train.

Power P_K' delivered to gear K' from gear A' in the first component train is

$$P_K' = P_A' \, \eta' = P_i \, R' \, \eta' \qquad (45)$$

Table 1—Planetary Gear Train Analysis

	Gear A	Gear B	Gear C	Gear J	Ring Gear K	Planet Carrier G
Train locked	+1	+1	+1	+1	+1	+1
Planet carrier stationary	$-\frac{N_K}{N_J}\left(-\frac{N_B}{N_A}\right)$	$-\frac{N_K}{N_J}$	$-\frac{N_K}{N_J}\left(\frac{N_B}{N_C}\right)$	$-\frac{N_K}{N_J}$	−1	0
Total rotation	$1 + \frac{N_K}{N_A}$	$1 - \frac{N_K}{N_J}$	$1 - \frac{N_K}{N_C}$	$1 - \frac{N_K}{N_J}$	0	+1

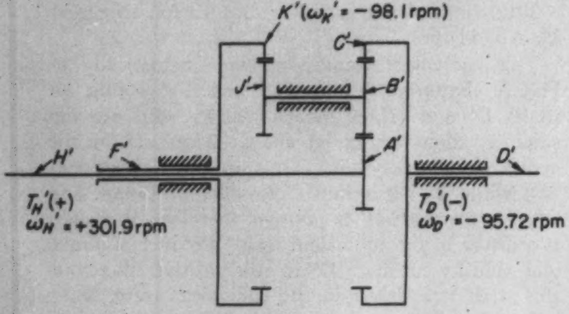


Fig. 8—Equivalent gear train for differential planetary gear system shown in Fig. 7.

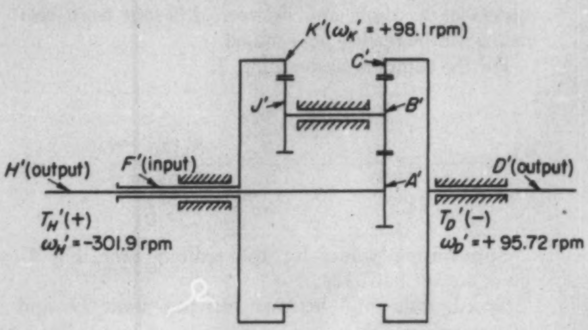


Fig. 9—Equivalent gear train for differential planetary gear system shown in Fig. 7 when direction of power flow is reversed.

where $\eta' =$ efficiency of a conventional gear train made up of gear pairs A'-B' and J'-K'.

Power P_C'' at gear C' in the second equivalent component gear train is

$$P_C'' = P_o R'' = P_i e_t R'' \tag{46}$$

where $R'' =$ planetary velocity ratio of the second component train.

Power P_K'' delivered to gear K' from gear C' in the second component train is

$$P_K'' = P_i e_t R'' \eta'' \tag{47}$$

where $\eta'' =$ efficiency of an internal gear drive made up of gear pairs C'-B' and J'-K'.

Tooth-mesh power losses in the component equivalent trains are

$$L' = P_A' - P_A' \eta' = P_i R'(1 - \eta') \tag{48}$$

$$L'' = P_C'' - P_K'' = P_i e_t R''(1 - \eta'') \tag{49}$$

Total power loss, which is the same in equivalent and actual systems, can be determined from

$$L_t = L' + L'' = P_i[R'(1 - \eta') + e_t R''(1 - \eta'')] \tag{50}$$

Efficiency of the actual system, when power is transmitted from shaft H to shaft D, is

$$e_t = \frac{P_i - L_t}{P_i} = \frac{1 - R'(1 - \eta')}{1 + R''(1 - \eta'')} \tag{51}$$

Planetary velocity ratio R' for first equivalent component train can be determined from

$$R' = \frac{\omega_H'}{\omega_H} = \frac{\omega_A'}{\omega_A} \tag{52}$$

where ω_H' and ω_A' are velocities of shaft H' and gear A' in the first component train. For the reducer, Fig. 6, $R' = 301.9/400 = 0.755$.

Planetary velocity ratio R'' for the second equivalent component train is

$$R'' = \frac{\omega_C'}{\omega_C} = \frac{\omega_D'}{\omega_D} \tag{53}$$

where ω_C' and ω_D' are velocities of gear C' and shaft D' in the second component train. For the reducer unit, $R'' = -95.72/2.393 = -40$. In efficiency calculations, only the absolute value of the planetary velocity ratio should be used.

Assume efficiency for an external gear pair is 0.98 and for an internal gear pair is 0.99. Then, $\eta' = 0.98(0.99) \approx 0.97$ and $\eta'' \approx 0.99(0.99) = 0.98$. From Equation 51, $e_t = 0.54$ which is the efficiency of the planetary reducer, Fig. 6, under the assumed conditions when power is transmitted from shaft H to shaft D.

To find out if this reducer is self-locking, the planetary system must be analyzed for the condition where power is transmitted from shaft D to shaft H.

Assume shaft D (Fig. 7) is the driving shaft in the system and rotates counterclockwise at a speed of $\omega_D = \omega_C = -2.39$ rpm. Driven shaft H also rotates in a negative direction at a speed, $\omega_H = \omega_A = -400$ rpm. Speed of the planet carrier, then, is $\omega_G = -98.11$ rpm. Since ω_D is now negative and shaft D is a driver, external torque T_D at this shaft must be negative, while torque T_H at driven shaft H must be positive.

To obtain the equivalent gear train, angular velocity $-\omega_G$ must be added to the entire system. In this equivalent train, $\omega_D' = -2.39 + 98.11 = 95.72$ rpm, $\omega_A' = -400 + 98.11 = -301.9$ rpm, and $\omega_K' = 0 + 98.11 = 98.11$ rpm.

This equivalent train is shown in Fig. 9. External torques acting on shafts H' and D' are the same as those in the actual system.

Product of angular velocity and torque at shaft D' is negative. Thus, this shaft is a driven member in the equivalent gear train. Product of torque T_H' and angular velocity ω_A' is also negative. Therefore, shaft H' is also a driven member in this train. Consequently, shaft F' with ring gear K' must be the driving member.

Two component trains can be identified. The first train, consisting of gears K', J', B', and A', transmits power from shaft F' to shaft H'. The second train, consisting of gears K', J', B', and C', transmits power from shaft F' to shaft D'. Relationship between output power P_o at shaft H and input power P_i at shaft D in the actual train is given by Equation 43.

Power P_H' at shaft H' in the first component train is

$$P_H' = P_o R' = P_i e_t R' \tag{54}$$

Power P_D' at shaft D' in the second component train is

$$P_D' = P_i R'' \tag{55}$$

Power P_K' developed at gear K', which is the driving member for the entire equivalent gear train, consists of two components. One component P_K' is transmitted by gears K', J', B', and A' to shaft H'. It is

$$P_K' = \frac{P_H'}{\eta'} = \frac{P_i e_t R'}{\eta'} \tag{56}$$

The other component, P_K'' is transmitted to shaft D' by gears K', J', B', and C'. It is

$$P_K'' = \frac{P_D'}{\eta''} = \frac{P_i R''}{\eta''} \tag{57}$$

Tooth-mesh power losses in the equivalent component trains are

$$L' = \frac{P_i e_t R'(1 - \eta')}{\eta'} \tag{58}$$

$$L'' = \frac{P_i R''(1 - \eta'')}{\eta''} \tag{59}$$

Total power loss in the actual system when power is transmitted from shaft D to shaft H is

$$L_t = L' + L'' = P_i \left[\frac{e_t R'(1 - \eta')}{\eta'} + \frac{R''(1 - \eta'')}{\eta'} \right] \quad \ldots\ldots (60)$$

Efficiency of this planetary system is

$$e_t = \frac{P_i - L_t}{P_i} = \frac{\eta'[\eta'' - R''(1 - \eta'')]}{\eta''[\eta' + R'(1 - \eta')]} \tag{61}$$

As in the previous analysis, $R' = 0.755$, $R'' = -40$, $\eta' = 0.97$, and $\eta'' = 0.98$. From Equation 61, then, $e_t = 0.176$. Since this efficiency value is larger than zero, the planetary reducer is not a self-locking mechanism under the assumed conditions.

Efficiency relationships for the condition of self-locking can be determined from Equation 61. Self-locking begins when efficiency e_t becomes zero. To meet this requirement, the following relationship must be satisfied:

$$\eta'' - R''(1 - \eta'') = 0 \tag{62}$$

For the system under consideration, this relationship becomes

$$\eta'' = 40(1 - \eta'')$$

$$\eta'' = \frac{40}{41} = 0.976$$

Thus, if the efficiency η'' of the second component equivalent gear train, which consists of two pairs of internal gears (J'-K' and B'-C'), is less than 0.976, the planetary gear system is self-locking and will transmit power in one direction only, from shaft H to shaft D. However, in practice, operating conditions may have an influence on this characteristic. Vibrations which usually develop in the operation of gear drives may reduce substantially the value of η'' required for self-locking.

Tips and Techniques

Multiplying Constants

When it is necessary to repeatedly multiply a constant such as e or π by a decimal number, considerable time can be saved by tabulating values for the constant from 1 to 9. The decimal point in the tabulation is simply moved to correspond to that of the multiplier. The tabulated value for each digit of the multiplier is set down with the proper decimal point and the answer is obtained by adding. The following is a typical tabulation:

Number	π	$\log_e 10$	$\log_{10} e$
1	3.14159	2.30259	0.43429
2	6.28318	4.60517	0.86859
3	9.42477	6.90776	1.30388
4	12.56636	9.21034	1.73717
5	15.70795	11.51293	2.17247
6	18.84954	13.81551	2.60776
7	21.99113	16.11810	3.04105
8	25.13272	18.42068	3.47434
9	28.27431	20.72327	3.90864

EXAMPLE: To find the value of 1.932π using the tabulated values,

$$\begin{aligned} 1 \times \pi &= 3.14159 \\ 0.9 \times \pi &= 2.827431 \\ 0.03 \times \pi &= 0.094248 \\ 0.002 \times \pi &= \underline{0.006283} \\ 1.932 \times \pi &= 6.06955 \end{aligned}$$

—DR. P. J. BHATT, *Loughborough, England*

An Engineering Approach to HYDRAULIC LINES | NO. 5

Selecting Hydraulic Hose

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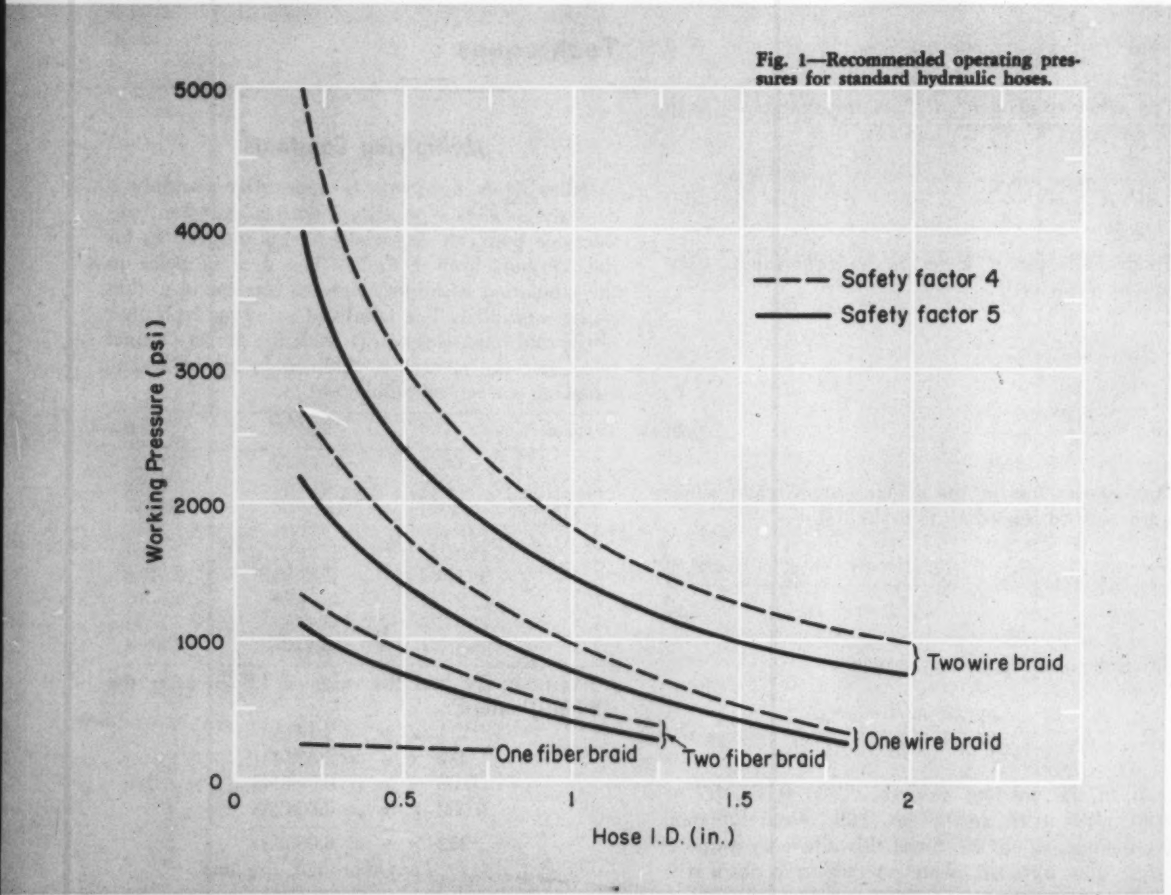


Fig. 1—Recommended operating pressures for standard hydraulic hoses.

WHENEVER there is relative motion between two components in a hydraulic system, the line used for connection should be flexible hydraulic hose. Rigid hydraulic lines may not be able to resist the stresses set up by appreciable vibrations. Here also, flexible hose is the practical solution.

Flexible hose is not as flexible as often believed. For example, hose constructions for high-pressure applications require thick walls with heavy steel-mesh reinforcement. Hence, the hose can be bent only in large radiuses. For the same reason, the length of hose must be accurately determined. This is especially true when hoses of large diameters are involved, or when the length of connection is short.

To help in selecting the hose most suitable for a specific application, this article presents standardized specifications and recommended applications for flexible hoses.

Specifications

The types of hose most frequently used in industrial hydraulic systems have been standardized by SAE. The following discussion briefly summarizes the types of hose which are covered by SAE Standards. Complete descriptions, sizes, and properties for these standardized hoses are found in Table 1.

High Pressure (SAE 100R2): Double wire braid, rubber-covered hose.

Medium High Pressure (SAE 100R1): Single wire braid, rubber-covered hose.

Medium High Pressure (SAE 100R5): Single wire braid, cotton-covered hose. This type of hose follows a dimensioning procedure which differs from all other hose types.

Medium Pressure (SAE 100R3): Double fiber braid, rubber-covered hose.

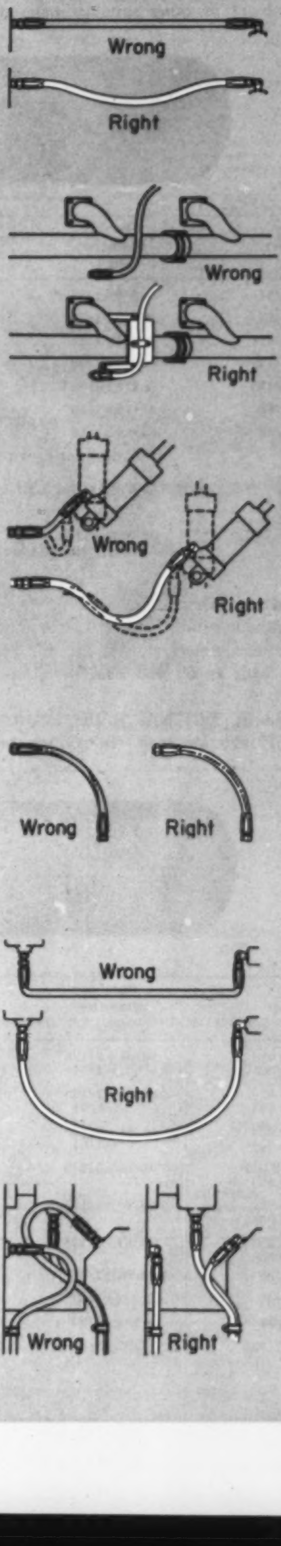
Suction Line Hose (SAE 100R4): Wire-spiral and closed hose to prevent collapsing under vacuum.

Low-pressure hose is not standardized. The commercially available types include the various fabric-braid hoses with one or two braids. Quality and construction of low-pressure hose vary somewhat between manufacturers.

In all the SAE standardized types, the specifications are followed closely by manufacturers. This permits complete interchangeability between hoses of the same type, regardless of source.

The following SAE specifications are common to

Fig. 2—Recommended Hose Installations.



Provide slack or bend in the hose to compensate for any changes in length which might occur.

When hose lines pass close to a hot exhaust manifold, protect the hose with a fireproof boot or metal baffle.

When a hose assembly is to be subjected to considerable flexing or vibration, remember that metal hose fittings are not part of the flexible portion.

If high operating pressures are applied to a twisted hose, the hose may fail or the attaching nut become loose.

Keep the bend radius of the hose as large as possible to avoid collapsing of line and restriction of flow.

Use elbows and adapters to insure easier, cleaner installations for quick inspection and maintenance.

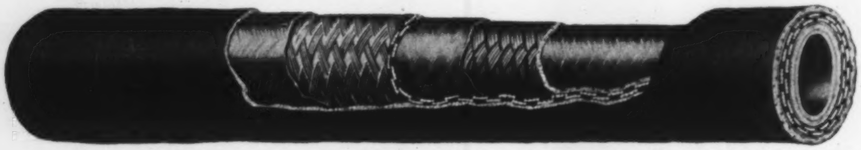
Table 1—Characteristics, Dimensions

Single Wire Braid, Rubber-Covered Hose (SAE 100R1)

Construction: The hose shall consist of a seamless oil-resistant synthetic-rubber tube, one braid of high-tensile steel wire, and an oil and weather-resistant synthetic rubber cover. A cotton braid or other suitable material may be used to anchor the cover to the hose.

Vacuum: 30-in. Hg through ½-in. ID, 20-in. Hg up to ¾-in. ID.

Applications: Medium high-pressure hydraulic systems.

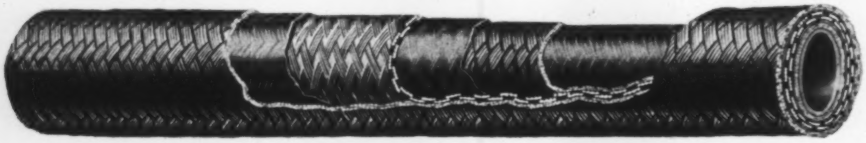


Inside Diameter (in.)	Outside Diameter (in.)	Min Burst Pressure (psi)	Max Working Pressure (psi) for Safety Factor of		Max Length Change Under Working Pressure (per cent)	Min Bend Radius (in.)
			4	5		
1/4±1/64	5/8±1/32	10,000	2500	2000	+0, −6	4
3/8±1/64	25/32±1/32	8,000	2000	1600	+2, −4	5
1/2±3/128	29/32±1/32	7,000	1750	1400	+2, −4	7
3/4±3/128	1 3/16±1/32	5,000	1250	1000	+2, −4	9 1/2
1±3/128	1 1/2±3/64	4,000	1000	800	+2, −4	11
1 1/4±1/32	1 13/16±1/16	2,500	625	500	+2, −4	16
1 1/2±1/32	2 1/16±1/16	2,000	500	400	+2, −4	20

Single Wire Braid, Cotton-Covered Hose (SAE 100R5)

Construction: The hose shall consist of a seamless oil-resistant synthetic-rubber tube and two cotton braids separated by a high-tensile steel wire braid. All braids are to be impregnated with an oil and mildew-resistant synthetic-rubber.

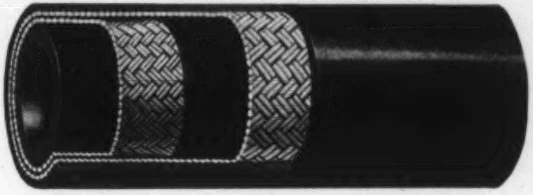
Applications: This hose is the industrial version of the MIL-H-5511 aviation hose. In performance, it is equivalent to the one wire-braid rubber-covered SAE 100R1 hose, but has greater flexibility. It is made to different ID dimensions than all the rest of the hydraulic hoses following the aviation practice to deduct from the OD of the connecting tubing twice the wall thickness to determine the required equivalent ID of the hose.



Inside Diameter (in.)	Outside Diameter (in.)	Min Burst Pressure (psi)	Max Working Pressure (psi) for Safety Factor of		Max Length Change Under Working Pressure (per cent)	Min Bend Radius (in.)
			4	5		
3/16+0.016 −0.005	33/64+3/128 −1/64	12,000	3000	2400	+0, −6	3
1/4+0.020 −0.008	37/64+3/128 −1/64	10,000	2500	2000	+0, −6	3 3/8
5/16+0.023 −0.008	43/64+3/128 −1/64	9,000	2250	1800	+2, −4	4
13/32+0.023 −0.008	49/64±3/128	8,000	2000	1600	+2, −4	4 5/8
1/2+0.023 −0.008	59/64±3/128	7,000	1750	1400	+2, −4	5 1/2
5/8+0.023 −0.008	1 5/64±3/128	6,000	1500	1200	+2, −4	6 1/2
7/8±1/32	1 15/64±1/32	3,200	800	650	+2, −4	7 3/8
1 1/8±1/32	1 1/2±1/32	2,500	625	500	+2, −4	9
1 3/8±1/32	1 3/4±1/32	2,000	500	400	+2, −4	10 1/2
1 13/16±1/32	2 7/32±3/64	1,400	350	280	+2, −4	13 1/4

and Properties for Flexible Hydraulic Hose

Double Fiber Braid (nonmetallic), Rubber-Covered Hose (SAE 100R3)



Construction: The hose shall consist of a seamless oil-resistant synthetic-rubber tube, two plies of high-tenacity rayon or other suitable material, and an oil and weather-resistant synthetic-rubber cover.

Vacuum: 25-in. Hg through ¾-in. ID, 10-in. Hg through 1-in. ID and larger.

Applications: Medium and low-pressure systems.

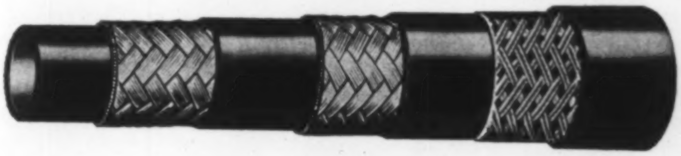
Inside Diameter (in.)	Outside Diameter (in.)	Min Burst Pressure (psi)	Max Working Pressure (psi) for Safety Factor of		Max Length Change Under Working Pressure (per cent)	Min Bend Radius (in.)
			4	5		
1/4±1/64	9/16±1/32	5000	1250	1000	+2, −4	3
3/8±1/64	3/4±1/32	4500	1125	900	+2, −4	4
1/2±3/128	15/16±1/32	4000	1000	800	+2, −4	5
3/4±3/128	1 1/4±1/32	3000	750	600	+2, −4	6
1±1/32	1 1/2±3/64	2250	550	470	+2, −4	8
1 1/4±1/32	1 3/4±1/16	1500	375	300	+2, −4	10

Double Wire Braid, Rubber-Covered Hose (SAE 100R2)

Construction: The hose shall consist of a seamless oil-resistant synthetic-rubber tube and two plies of high-tensile steel wire, and an oil and weather-resistant synthetic-rubber cover. A cotton braid or other suitable material may be used to anchor the cover to the hose.

Vacuum: 30-in. Hg up to ½-in. ID.

Application: High-pressure systems.



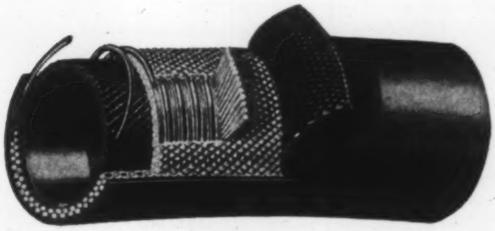
Inside Diameter (in.)	Outside Diameter (in.)	Min Burst Pressure (psi)	Max Working Pressure (psi) for Safety Factor of		Max Length Change Under Working Pressure (per cent)	Min Bend Radius (in.)
			4	5		
1/4±1/64	11/16±1/32	18.000	4500	3600	+0, −6	4
3/8±1/64	27/32±1/32	14,000	3500	2800	+2, −4	5
1/2±3/128	31/32±1/32	12,000	3000	2400	+2, −4	7
3/4±3/128	1 1/4±1/32	9,000	2250	1800	+2, −4	9 1/2
1±1/32	1 9/16±3/64	7,500	1850	1500	+2, −4	11
1 1/4±1/32	2±1/16	6,500	1625	1300	+2, −4	16
1 1/2±1/32	2 1/4±1/16	5,000	1250	1000	+2, −4	20
2±1/16	2 3/4±1/16	4,000	1000	800	+2, −4	22

Wire Insulated Suction Hose (SAE 100 R4)

Construction: The hose shall consist of a seamless oil-resistant rubber tube, a circular-woven reinforcement consisting of cotton, rayon, or other suitable warps and alternate wire and cotton, rayon, or other suitable fillers, and an oil and weather-resistant synthetic-rubber cover.

Vacuum: 25 in. Hg.

Applications: The wire insert will prevent the hose from collapsing under vacuum.



Inside Diameter (in.)	Outside Diameter (in.)	Min Burst Pressure (psi)	Min Bend Radius (in.)
3/4±1/32	1 3/8	1200	5
1±1/32	1 5/8	1000	6
1 1/4±3/64	2	800	8
1 1/2±3/64	2 1/4	600	10
2±1/16	2 3/4	400	12
2 1/2±1/16	3 1/4	250	14

all types of hose: 1. Proof pressure shall be 50 per cent of the minimum burst pressure. 2. Maximum working pressure shall be 25 per cent of the minimum specified burst pressure, i.e., a safety factor of 4 shall be used. 3. The hose shall be designed to operate through a temperature range of −40 to +200 F when used under normal operating conditions. Operating temperatures in excess of 200 F may materially reduce the life of the hose. 4. The entire length of hose shall be legibly marked parallel to the longitudinal axis of the hose with a stripe or stripes showing SAE part number and size which must be repeated not less than every 18 in.

The JIC Standards refer only briefly to the use of flexible hose as follows: "In all portions of piping circuits above 150 psi operating pressure subject to movements in which flexible hose is required, the flexible hose selected shall provide a pressure safety factor of at least five (5) with respect to the circuit in which it is used. Below 150 psi operating pressure, the use of flexible plastic tubing shall be permissible. Flexible hose and flexible plastic tubing shall have vertical connections and shall have sufficient slack to avoid sharp flexing and straining. Horizontal connections are acceptable only if flexible lines are adequately supported."

Notice that the JIC standards call for a safety factor of 5, while the SAE standard requires only a safety factor of 4. Most of the hose assembly manufacturers and users adhere to the SAE practice which is assumed to be adequate. However, circuits which must meet JIC specifications must employ hose that reflects the required factor of 5. This limits the use of hose to considerably lower pressures. The curves in Fig. 1 give the permissible working pressures of the standard hose types for both safety factors.

Size Specifications: Flexible hose is preferably specified according to inside diameter. This practice is necessary since the construction of braids and rubber covers may vary in thickness. There is one exception to this rule. For SAE 100R5 type hose the specifications are often made by size number, which refers to an equivalent tubing ID. However, this specification is not quite consistent, because of variations in the interpretation of the "equivalent" tubing size. As a result, this type of hose has a dimensional series entirely different from other types of hose and requires special fittings.

Applications

The main characteristics and rules which should be followed in applying hydraulic hose are:

1. Use flexible hose wherever there is relative motion or vibration between connected components.
2. For long distances, use only short flexible hose connections transistioning to tubing. This type of connection promotes heat dissipation.
3. The installed hose should be free of any twists or bends smaller than the recommended minimum. Small bends decrease the life of the hose considerably. Also, a minimum straight run distance from a fitting should be carefully maintained to avoid biting into the hose by the fitting edge.
4. Elasticity of hose absorbs a portion of the hydraulic shocks generated in the system. The swelling which results in the hose causes length decreases which must be taken into account for hose dimensioning.
5. Standard flexible hoses are compatible with oil-base hydraulic fluids, but may swell when used with phosphate base fire-resistant fluids.
6. The operating temperature should be maintained within the specified range. Hose should be protected from contact with high-temperature bodies such as exhaust pipes.
7. Since hose is substantially more expensive than tubing, its use should be limited to applications where it is really needed. However, ease of installation in tight spots and ease of relocation makes flexible hose preferable on many experimental installations.

Fig. 2 shows some of the right and wrong applications of hydraulic hose which are most frequently encountered in industrial hydraulic systems.

The sixth article in this planned program on hydraulic lines, "Selecting Hydraulic Connections," will discuss the various types of pipe, tube, and hose fittings, and when each type should be used for maximum efficiency. Previous articles in this program have appeared in the April 16, 30, May 14, and 28 issues of MACHINE DESIGN.

ACKNOWLEDGMENT

MACHINE DESIGN acknowledges with appreciation the co-operation of these companies in supplying photos and illustrations:

Aeroquip Corp. (Fig. 2, Table 1—SAE types 100R1, 100R5) .... Jackson, Mich.

Anchor Coupling Co. (Table 1—SAE types 100R2, 100R3, 100R4) .... Libertyville, Ill.

They Say . . .

"Education must inspire us to think, question, and probe, not drown us in data, charts, and techniques. If we need data where it's not known, search it out. If we need charts, compile and reduce our data findings. If we need techniques, gain the experience by questioning the past against the spectrum of our knowledge, inspiration, physical abilities, and talents."—SAMUEL L. FAHNESTOCK, *chief industrial designer, Aluminum Co. of America.*

"The basic fault of engineers as a group . . . is that they are subject to many of the ills of group psychology. The herd instinct begins to show itself. The engineers try to draw strength and support from each other. There is a tendency for them to differentiate themselves from other employees, to seek special recognition and privileges, to strive . . . for professionalism and sometimes to choose their own bargaining unit. As a result the engineer often draws further and further away from management and finds it increasingly difficult to see what the objectives of the business are and what business expects of him as an employee."—CARLTON BARLOW, *director of personnel development, General Dynamics Corp.*

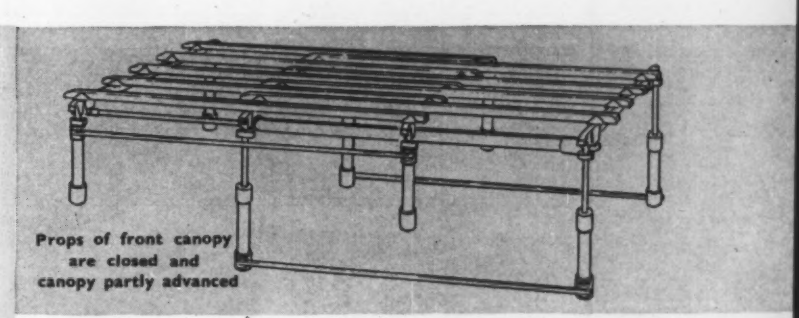
Self-Advancing Support Structure "Walks" on Telescoping Columns

ADJUSTABLE-LENGTH LEGS in the form of eight hydraulic cylinders permit a shield-and-support system for underground mining to walk forward or backward. The protective shield comprises two interlocking canopies which can be slid apart or brought back together by two long, horizontal hydraulic cylinders.

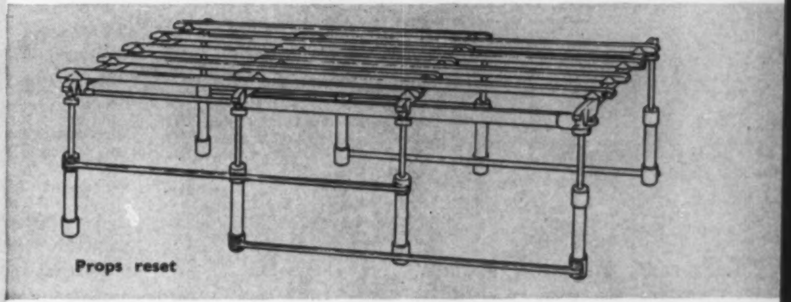
Four lever-operated control valves operate the unit. One valve varies the length of all four columns or legs on one interlocking canopy while a second valve operates the legs on the other canopy. A third valve controls one of the horizontal cylinders and the fourth the other. Individual valve controls on the horizontal cylinders make it possible to steer the self-advancing support system.

An electric-motor driven pump provides the necessary hydraulic pressure which is in the 1000 to 1500 psi range. The structure can withstand 8 tons of point loading and is designed to collapse to a minimum height of about 4 ft.

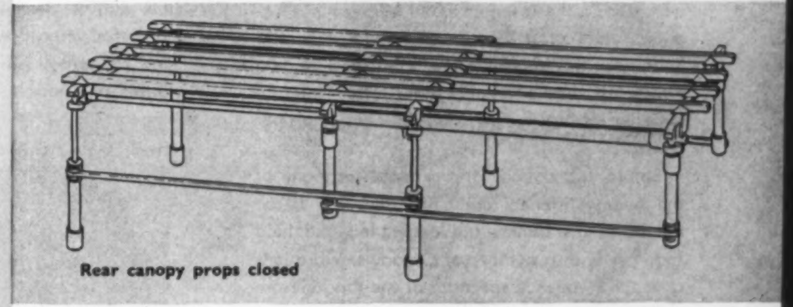
The shield is manufactured by Dowty Mining Equipment Ltd., Ashchurch, England. It was designed specifically for room-and-pillar and block-extraction mining by R. D. Josephs, Safety and Health Engineer, U. S. Bureau of Mines.



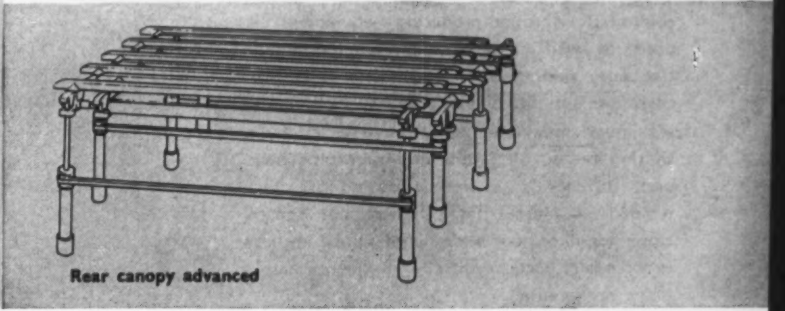
Props of front canopy are closed and canopy partly advanced



Props reset

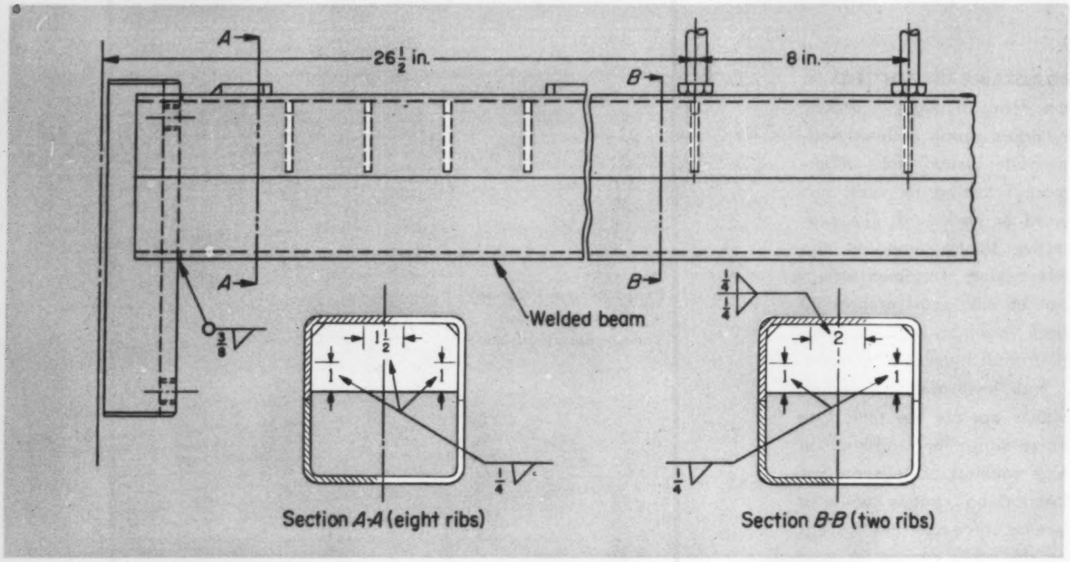


Rear canopy props closed



Rear canopy advanced

Plates Welded in Formed Beams Lower Resonant Vibration Frequency

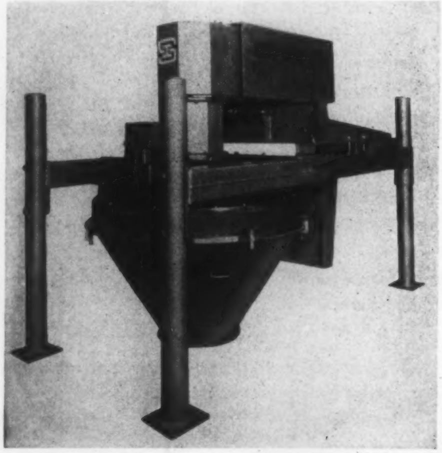


BEAM VIBRATION PROBLEMS are eliminated with accurately located welded-in stiffeners which bring the resonant point below the operating range of a centrifugal impact mill. The beams in this machine are fabricated in two halves of brake-formed plate after internal stiffener plates are welded in at the proper points.

Before fabrication, approximate locations of the beam stiffeners are calculated. The beam halves and stiffeners are assembled and held together with a number of C-clamps. Vibrations over the frequency spectrum of the machine are induced into the end of each beam. Special controlled vibration-producing equipment is used, as well as a vibration amplitude-and-frequency sensing unit. Frequencies in 200-cycle increments are induced into the beam and maximum amplitude points are detected by a sensing probe. By a trial-and-error procedure, each stiffener is accurately located and tack welded in place. The stiffeners are spaced closer together near the ends of the beam than in the center because vibration-frequency amplitudes are greater there.

As reported by Arnold J. Tenner, chief engineer, Safety Industries Inc., New Haven, Conn., this mill is designed with a 40-in. diameter rotor for impact velocities above 30,000 fpm and can process more than 100,000 lb of materials per hour.

Photo, courtesy Lincoln Electric Co.



Pressure-Sensitive Conveyor Automatically Spaces Loads

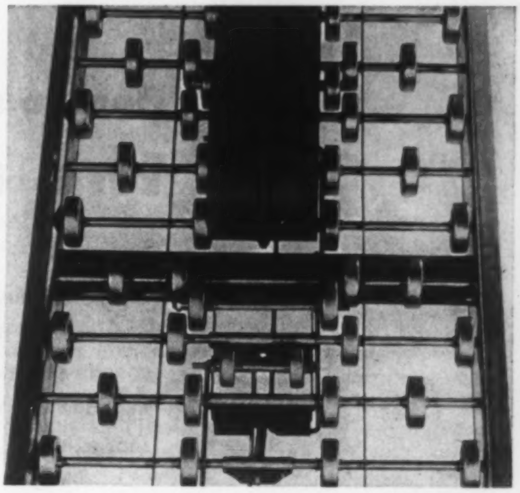
ADJUSTABLE-PRESSURE WHEEL ASSEMBLIES at equally spaced points under the length of a conveyor belt permit individual control of travel of loaded cartons on the conveyor. When cartons are fed on the combination powered-belt and gravity-wheel conveyor, pressure-sensing devices in the system automatically space out the cartons to simplify counting and to facilitate movement on curves, transfers, and inclines. Likewise, if an accumulation of cartons occurs at any one point, the system automatically stops the cartons, one at a time, while the conveyor belt continues to run at full speed.

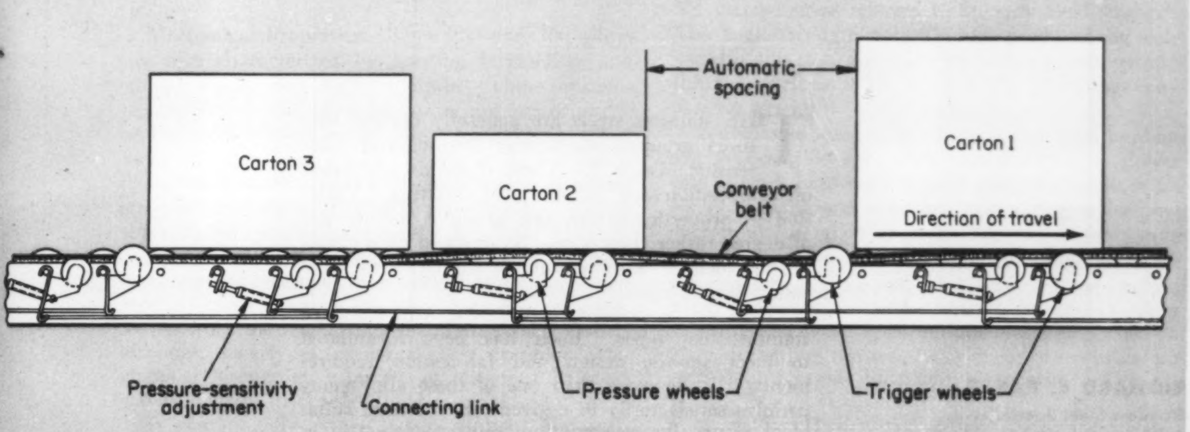
CARTON STARTING AND STOPPING on the conveyors is controlled by automatic adjustment of belt height. Motion is imparted to the loaded cartons when the belt is raised above the load-bearing wheels into contact with the carton bottoms. Pairs of pressure wheels, which are located at regular intervals under the belt, control belt height at each interval. Each pair of pressure wheels is actuated by a pair of trigger wheels through a connecting link.

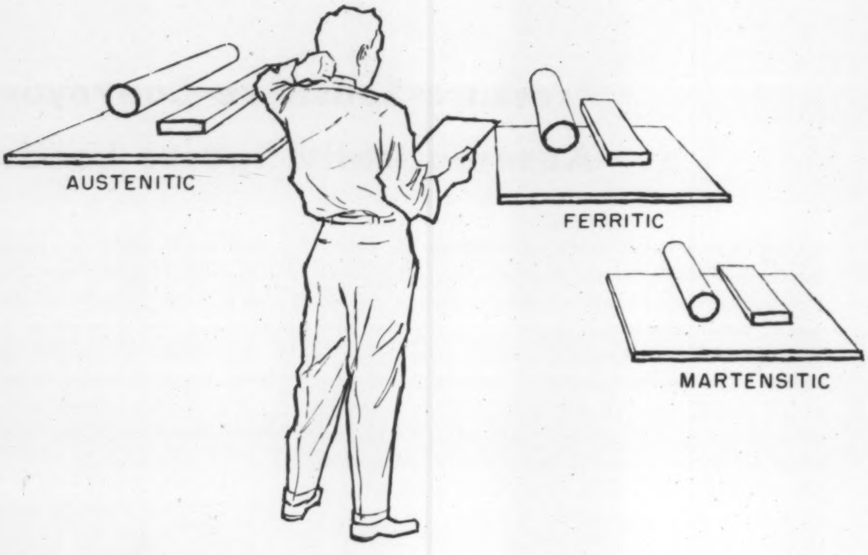
When there is a load on the trigger wheels, the link-connected pair of pressure wheels are pulled down, dropping the belt below the load-bearing wheels. When the load moves off of the trigger wheels, the belt is lifted automatically to engage the following container. This series of actions spaces the cartons when they are fed on to the conveyor or stops the cartons without line pile-up if they accumulate.

Adjustment of a locknut against a compression spring controls load sensitivity of the pressure-wheel assembly.

The pressure-sensing conveyor was developed by Rapids-Standard Co. Inc., Grand Rapids, Mich.







How to select
the right stainless

Of the dozens of stainless alloys available, it isn't always easy to pick exactly the right one for a particular application. Here's a concise selection guide—including an alloy classification, properties and applications of most-used types, and available mill shapes and finishes.

THE stainless steels are generally divided into three groups: Austenitic, ferritic, and martensitic, Table 1. These divisions are based on composition and metallurgical structure. Variation in properties in any one group is mainly one of degree rather than kind. So steels in each classification behave with reasonable similarity to processing treatments.

There are, at present, 37 different AISI standard stainless-steel types. Each has been formulated to meet specific design and fabrication requirements. While more than one of these alloys may perform satisfactorily in a given job, the most suitable one usually results in an improved product at lowest possible cost.

RICHARD E. PARET
Stainless Steel Specialist
American Iron and Steel Institute
New York, N. Y.

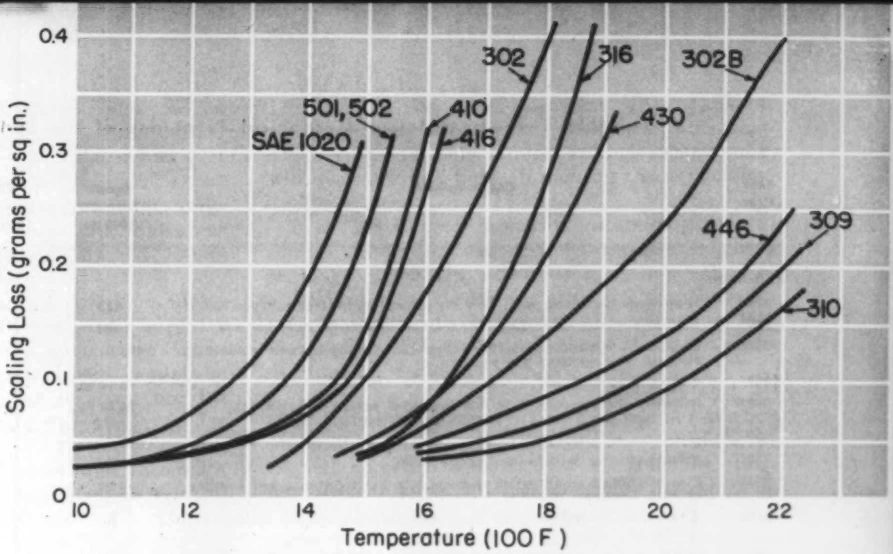


Fig. 1—Scaling losses of various types of stainless steels. Losses were developed on a 12-period intermittent heating-cooling cycle.

steel

Austenitic Stainless Steels

This group includes 22 different alloys in the AISI standard 200 and 300 series, Table 1. Austenitic steels are the most widely used and have the highest corrosion resistance of all stainless alloys. They also claim the greatest strength and scale resistance at elevated temperatures of all stainless and heat-resisting steels and retain ductility at temperatures approaching absolute zero.

Mechanical Properties: Type 200 and 300 alloys are also characterized by unusual formability and ability to develop high strength. These austenitic grades, in the annealed state, are nonmagnetic and possess maximum ductility, comparatively low yield strength, high impact strength, and freedom from notch effect. Tensile strength in the annealed state is approximately 90,000 psi compared to less than 50,000 psi for mild steel.

Austenitic steels cannot be hardened by heat treatment, but can be cold worked to produce high tensile strengths and improved elastic properties. When work hardened, they maintain good ductility, although most types become slightly magnetic. Mechanical properties attained at different tempers are compared in Table 2.

By changing the proportions of alloying elements, or by adding supplementary elements, stainless steel can be altered to meet specific engineering requirements. Ultimate strength (tension and compression) and ductility are the mechanical properties of stainless most influenced by chemical composition. Yield strength and modulus of elasticity are influenced relatively little.

Stainless Type 301 is generally selected for applications where strength, ductility, and good corrosion resistance are essential. This steel has a high work-hardening rate and is supplied in five different tempers, Table 2. When cold worked, Type 301 can be stress relieved to increase yield strength. The high strength-weight ratio, produced by cold working this steel and other austenitic grades, permits thinner sections to be used while providing comparable strength.

Whereas an alloy with a high rate of work hardening is desirable for many applications, a slower rate of work hardening is more desirable in alloys for severe drawing and spinning. For rolling or forming operations, an alloy must be selected which has a proper rate of work hardening in the range of plastic deformation. Nickel, and to a lesser extent carbon, most influences the rate of strain hardening when spinning and forming chromium-nickel steels with a given chromium content. As the nickel-to-chromium ratio is increased, formability increases.

Annealing: Type 305 fulfills the need for a stainless steel with minimum work-hardening qualities

Table 1—Representative Mechanical Properties of the Stainless Steels

AISI Type	Characteristic	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Elongation (per cent)	Hardness (Rockwell B)
Austenitic					
201	High work-hardening rate. Low Ni content equivalent to Type 301.	115	55	55	90
202	General-purpose steel. Low Ni content equivalent to Type 302.	105	55	55	90
301	High work-hardening rate. For structural applications and where high strength and ductility are required.	105 to 110	40	55 to 60	85
302	General-purpose steel.	85 to 90	35 to 40	50 to 60	80 to 85
302B	Basically the same as Type 302 but more scale resistance.	90 to 95	40	50 to 55	85
303	Free-machining modification of Type 302.	90	35	50	—
303Se	Free-machining modification of Type 302. For light cuts, hot working, or cold heading.	90	35	50	—
304	Low-carbon modification of Type 302. Restricts carbide precipitation during welding.	85	30 to 35	50 to 60	80
304L	Lower carbon modification of Type 304. Further restricts carbide precipitation.	75	28	50	70
305	Low work-hardening rate. For spin forming and severe drawing.	85	35 to 38	50 to 55	80
308	High-alloy steel with high corrosion and heat resistance. For welding rods to compensate for alloy loss in welding.	85	30 to 35	50 to 55	80
309	For high-temperature strength and scale resistance.	90 to 95	40 to 45	45	83
309S	Low-carbon modification of Type 309. For welded construction.	90 to 95	40 to 45	45	85
310	Higher elevated-temperature strength and scale resistance than Type 309.	95	45	45 to 50	85 to 89
310S	Low-carbon modification of Type 310. For welded construction.	95	45	45 to 50	85 to 89
314	Better scale resistance than Type 310.	100	50	40 to 45	85
316	Higher corrosion resistance than Types 302 and 304. High creep strength.	80 to 90	30 to 40	50 to 60	78 to 85
316L	Low-carbon modification of Type 316. For welded construction.	80 to 90	30 to 40	50 to 60	78 to 85
317	Higher corrosion and creep resistance than Type 316.	85 to 90	40	45 to 50	85
321	For weldments subject to severe corrosive conditions and for service in 800 to 1600-F range.	85 to 90	30 to 35	50 to 55	80
347	Same as Type 321.	90 to 95	35 to 40	45 to 50	85
348	Same as Type 321.	90 to 95	35 to 40	45 to 50	85
Ferritic					
405	12 per cent Cr nonhardenable stainless steel. For weldments for which 12 Cr gives enough corrosion resistance.	65 to 70	40	25 to 30	75
430	General-purpose nonhardenable Cr stainless steel.	75	40 to 45	25 to 30	80
430F	Free-machining modification of Type 430.	75	40 to 45	25 to 30	80
430FSe	Free-machining modification of Type 430 where hot working or cold heading is involved.	80	55	25	—
446	High resistance to corrosion and scaling at high temperatures especially for intermittent service. Often used in preference to Cr-Ni types in sulfur atmospheres.	80 to 85	50 to 55	20 to 25	83 to 86
Martensitic					
403	For steam turbine blading and other highly stressed parts.	65 to 75	35 to 40	25 to 35	80 to 82
410	General-purpose heat-treatable stainless steel.	65 to 75	35 to 40	25 to 35	80 to 82
414	High hardenability steel.	115 to 120	90 to 105	15 to 20	—
416*	Free-machining modification of Type 410.	75	40	30	82
416Se	Free-machining modification of Type 410. For hot working or cold heading.	—	—	—	—
420	High-carbon modification of Type 410.	95	50	25	92
431	Special-purpose hardenable steel. Used where particularly high mechanical properties are required.	125	95	20	24
440A	Hardenable to higher hardness than Type 420. Good corrosion resistance.	105	60	20	95
440B	Cutlery grade for wear-resisting and high-hardness parts.	107	62	18	96
440C	Yields highest hardness of hardenable stainless steels. For balls and bearing races.	110	65	14	97

*All properties values for Types 416 through 440C are for bar stock.

and maximum ductility. It can be annealed to provide extreme softness. Slow heating or cooling the less stable and higher carbon types of austentic steel through the sensitizing range (800 to 1500 F) can cause chromium carbides to precipitate at grain boundaries. Chromium in the adjacent areas is depleted, causing somewhat lowered intergranular corrosion resistance.

Actually, corrosion resistance of chromium-nickel steels after precipitation is still more than adequate for most applications. Its effects, however, must be considered when weldments, which cannot be annealed to restore precipitated carbides, are intended for use in highly corrosive media or for service in the sensitizing range under corrosive conditions. In such cases, precipitation and chromium loss encountered during welding may be critical, producing vulnerable areas alongside of welds.

Carbon Content: A number of low-carbon analyses are compounded expressly to minimize or avoid sensitization during welding. Types 304, 309S, and 310S, each with a maximum carbon content of 0.08 per cent, are generally satisfactory for most requirements of ordinary service. The lower carbon content of these alloys increases the period of time for which they can be subjected to welding heat before harmful degrees of chromium carbide form.

Where welding methods require prolonged heating in the sensitizing range, or for applications where corrosive conditions are particularly severe, Types 304L or 316L should be specified. Carbon inclusion in these steels is held to 0.03 per cent maximum. This low amount of carbon is more stably soluble in austenite and restricts chromium carbide precipitation to negligible proportions.

For equipment designed to provide extended service in the 800 to 1500 F sensitizing range, or for intricate sections which require long welding heats, three stabilized grades of stainless steel are available. These are Types 321, 347, and 348, which contain additions of titanium, or columbium and tantalum. These elements have strong carbide-forming tendencies, and combine with all carbon present in the steel. The chromium content of the steel is thus available to provide maximum corrosion resistance.

The stabilized grades are particularly useful for supercritical applications in the atomic-energy field or for jet-engine parts where corrosion-resisting properties at elevated temperatures are essential.

High-Temperature Oxidation Resistance: The remarkable suitability of the stainless steels for a variety of uses is further illustrated by the number of alloys which resists excessive scaling or oxidation at temperatures to 2000 F and over. Scaling losses for these steels at various high temperatures are shown in Fig. 1. High chromium and silicon contents contribute most to good scale and heat resistance, although nickel contents of about 11 per cent also promote these properties.

Types 314, 310, 309, and 302B are the preferred austenitic grades when scale resistance for continuous or intermittent service is required. Type 310 also has the lowest coefficient of expansion of all chromium-nickel steels. Because of this characteristic, oxide scale formed at high temperatures will not crack and flake off due to repeated heating-cooling cycles.

Type 308 is used primarily for welding rods to compensate for the loss of alloying elements during welding. Type 310 also finds some application as a welding electrode for use with low-chromium alloys. In addition to compensating for chromium loss, the high nickel content of these alloys promotes ductility of weldments.

Corrosion Resistance: The molybdenum-bearing austenitic steels, Types 316, 316L, and 317, have the highest corrosion resistance of all standard stainless steels. Type 316 provides more resistance to pitting than other chromium-nickel steels and is valuable for service with brines, sulfur water, or halogen salts. These three stainless steels also have the highest creep strength of the austenitic alloys. Creep strength of Type 316 is compared to that of chromium and chromium-nickel austenitic types in Fig. 2.

Machinability: At least one free-machining steel has been developed for each of the three stainless groups. The high sulfur content of (or addition of selenium to) Types 303 and 303Se promotes good chip characteristics and helps overcome gumminess. As a result, these alloys provide a machinability

Table 2—Mechanical Properties of Austenitic Stainless Steels at Various Tempers

AISI Type	Temper	Tensile Strength[1] (1000 psi)	Yield Strength[1] (1000 psi)	Hardness[2] (Rockwell B)
201	Annealed	75	40	96
	¼ hard[3]	125	75	..
	½ hard[3]	150	110	..
	¾ hard[3]	175	135	..
	Full hard[3]	185	140	..
202	Annealed	75	40	96
	¼ hard[3]	125	75	..
301	Annealed	75	..	94
	¼ hard[3]	125	75	..
	½ hard[3]	150	110	..
	¾ hard[3]	175	135	..
	Full hard[3]	185	140	..
302	Annealed	75	..	94
	¼ hard[3]	125	75	..
304	Annealed	75	..	94
304L	Annealed	70	..	94
305	Annealed	70	...	94
309	Annealed	75	..	96
310	Annealed	75	..	96
316	Annealed	75	..	96
	¼ hard[3]	125	90	..
316L	Annealed	70	..	96
321	Annealed	75	..	94
347	Annealed	75	..	94 min
348	Annealed	75	..	94

1. Values are minimum. 2. Values are maximum unless otherwise noted. 3. Available in sheets and strips only.

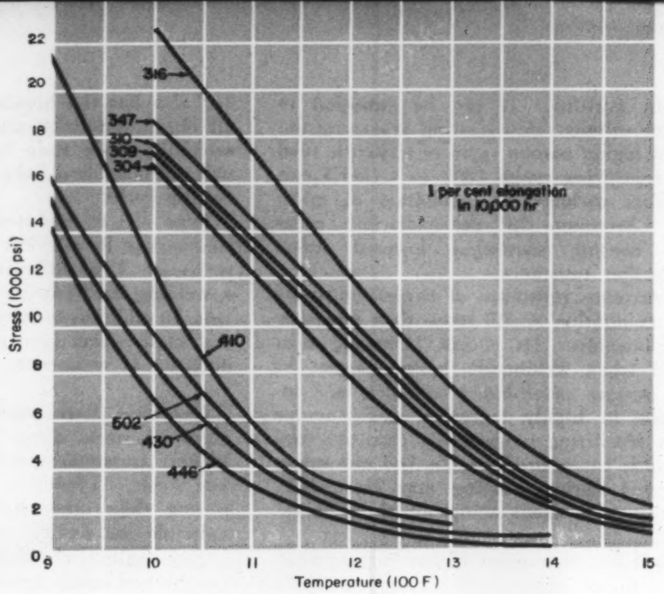


Fig. 2—Creep strength of chromium and chromium-nickel austenitic stainless steels.

of approximately 70 per cent of that of Bessemer screw stock, as compared to about 45 per cent for Type 302. In addition to the free-machining qualities which they impart, these supplementary agents also reduce seizing and galling tendencies. These improved qualities are of particular importance in applications where two movable surfaces are in contact. Transverse ductility in the free-machining grades is somewhat reduced, and the tendency to split must be considered in forging and upsetting.

Ferritic Stainless Steels

The low carbon-chromium ratio of steels in the ferritic group eliminates effects of thermal transformation and prevents hardening by heat treatment. Ferritic steels are magnetic, have good ductility, provide fair to exceptional machinability and are suitable for drawing, spinning, bending, and other methods of fabrication.

These steels also have good resistance to corrosion and oxidation due to their high chromium content and do not work harden to any significant extent. Another decided advantage is their relatively low coefficient of expansion which is less than that of austenitic steels and approximately equal to or less than that of carbon steel.

The ferritic steels do not tend to "throw" scale during intermittent heating and cooling and are frequently selected for high-temperature applications where this quality is useful. The applicability of Types 446 and 430 for intermittent high temperature service is shown in Fig. 1.

Type 430 is the general-purpose ferritic steel and is frequently used as an alternate for Type 302. It is particularly suitable for forming operations on cold-rolling mills. Excellent finishes are produced by this method which are easily enhanced by buffing to produce mirror finishes without intermediate polishing operations. Because of this characteristic, Type 430 is used extensively for trim, molding, and other decorative applications.

Mechanical and Physical Properties: Types 430F and 430Se have mechanical properties similar to Type 430. Increased sulfur content or addition of selenium, provides these alloys with the best machinability of all stainless steels—approximately 90 to 95 per cent that of Bessemer screw stock. They are an excellent choice for automatic screw machine work and volume production of precision parts which do not require an extremely high level of corrosion resistance.

Of all steels in the ferritic group, Type 446 offers the highest resistance to scaling at elevated temperatures and is particularly useful for applications involving intermittent service or with high sulfur-content in flue gas. In some cases, the alloy may be superior to nickel-bearing steels where these conditions are encountered. It is, however, inferior to nickel-bearing, high-temperature steels where strength at elevated temperatures or where toughness in cooled equipment is important.

Type 446 contains the greatest amount of chromium (23 to 27 per cent) and is endowed with the lowest coefficient of expansion of all stainless grades. This alloy has an expansion rate which approximates that of glass, which makes it particularly suitable for metal-to-glass sealing operations.

Addition of aluminum to Type 405 retards hardening and produces a low-chromium alloy specially modified for welding. Grain growth and brittleness which develop in ferritic steels of higher chromium content when exposed to elevated temperatures for extended periods of time are thus avoided. Type 405 weldments remain soft and more ductile without heat treatment. This alloy is especially useful for applications below 1200 F of welded assemblies which cannot be annealed and where corrosion-resisting properties of a 12 per cent chromium alloy are sufficient.

Martensitic Stainless Steels

Because of their carbon-to-chromium ratio, martensitic stainless steels are the only types hardenable by heat treatment. These alloys are also the most frequently used of the stainless family for fabricating mechanical components. Hardness, ductility, and ability to hold an edge, are characteristics of these alloys.

Mechanical and Physical Properties: Martensitic steels offer their best corrosion resistance and mechanical properties in the hardened state. Tensile strengths range from 70,000 to 105,000 psi for annealed alloys and from 125,000 to 200,000 psi for hardened alloys. These steels are magnetic in all conditions and possess the best thermal conductivity of the stainless types. Excellent for hot work and forging (if slow-cooled and annealed to prevent cracking), they provide fair machinability but are seldom used for forming.

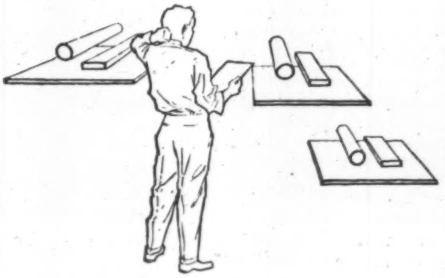
Type 410, the most widely used steel in this group, has high tensile strength, toughness, and resistance to impact when hardened. As with most martensitic steels, this alloy can be welded, but requires preheating and post heating. This is due to brittle martensite which forms on cooling from welding temperatures. Resistance to scaling at moderate temperatures enables Type 410 to be used at operating temperatures below 1200 F.

Types 414 and 420 are used as substitutes for Type 410 where greater hardness and strength are desired. Type 414 is used for making parts such as springs and valve seats. Surgical and dental instruments are excellent examples of Type 420 applications where spring properties and hardness are essential. Formability in these steels, however, is sharply restricted because of their hardness even after annealing.

Types 403 and 431 attain high mechanical properties by heat treatment. Type 403 is made to special quality requirements and was originally designed for steam-turbine blading. Here, resistance to particularly severe stress, wet erosion, corrosion, and abrasive wear are essential. When heat treated, Type 431 displays good impact values, ductility, and superior corrosion resistance to Types 410, 420, and 440. Type 431 has superior strength to Type 410, the basic martensitic steel, plus high yield point and resistance to shock.

The free-machining steels in the martensitic group are Types 416 and 416Se. They provide a machinability of approximately 90 per cent that of Bessemer screw stock. Type 416 has a high sulfur content which promotes good chip conditions and permits heavier cuts. Addition of selenium imparts good lubricating qualities to Type 416Se which is used for lighter cuts and for hot working or cold heading.

Types 440A, 440B, and 440C can be heat treated to provide greater hardness than all other stainless steels. They also contain the highest percentage of chromium of the hardenable steels and, consequently, have excellent resistance to corrosion.



Selecting forms and finishes

By specifying the most advantageous form and finish of stainless steel for a component in the design stage, the designer can contribute greatly to ease of fabrication and economy of the part. Following is a summary of specification data pertinent to the selection of mill-processed shapes including commonly available forms of stainless steel, their sizes, finishes, general applications, and special effects.

Sheets

Stainless-steel sheets are produced hot rolled or cold rolled and in coils or in cut lengths in specified thicknesses from 0.005 to 0.172 in. Generally, the thinner the sheet, the smoother the surface. When specified, cut lengths can be stretcher leveled or roller leveled after cold rolling for improved flatness, and can be ordered resquared to reduce camber of side edges.

Mechanical properties of the austenitic grades are greatly varied by cold working, and these steels can be obtained in a variety of tempers. When ordering sheets or plate, the dimension required as length should be indicated if direction of rolling is important.

Sheet Finishes: Available standard finishes and a general indication of suitability for particular fabricating procedures are:

No. 1—Hot rolled, annealed, and descaled. Generally used for heat and corrosion resistance where finish is unimportant or will be destroyed in fabrication.

No. 2D—Dull cold rolled, annealed, and descaled. Dull finish holds lubricants well, and sheets have maximum ductility and drawing quality. Generally specified for severe drawing operations which may be followed by polishing.

No. 2B—Bright cold rolled, annealed, and descaled. Sheet receives a final light cold-rolled pass on polished rolls. Finish is suitable for all but exceptionally difficult deep-drawing operations, and is more readily polished than a No. 1 or No. 2D finish.

No. 3—Intermediate polished finish. Used where a semi-finished polished surface is needed for subsequent finishing operations. Where additional finishing or polishing operations are not required, No. 4 finish is recommended.

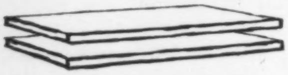
No. 4—General-purpose polished finish. Produced mechanically with abrasives, approximately 120 to 150 mesh. Used as a final finish for many products.

No. 6—Dull satin finish of lower reflectivity than No. 4 finish. Produced by Tampico brushing a No. 4 finish with abrasives and oil.

No. 7—High-luster polish. Produced by buffing finely ground surfaces, but grit lines are not removed.

No. 8—The most reflective finish commonly produced. Obtained by polishing with successively finer abrasives and buffing with extremely fine rouges for a mirror finish free from grit lines.

Polished finishes 3, 4, 6, 7, and 8 may be ordered for one or for both sides of the sheet. They are generally specified when forming operations will not damage the surface or when resulting blemishes can be blended easily. Appearance of these polished finishes may vary slightly among the different types of steel.



Plates

Stainless and heat-resisting steel plates are produced in thicknesses from 3/16 in., generally for heavy-duty applications. They are specified as either sheared mill plates or universal mill plates.

Sheared plates are rolled, and trimmed on all edges. Universal plates are rolled flat, edges are rolled with flat or grooved rolls, and plates are trimmed on the ends. Textured plates, of a type used on stairs and ladders, for example, are available for many other applications. Dimensions specified when ordering should always include adequate allowance for clean-up cuts following machining or flame-cutting operations.

Condition and Finish: Plates may be supplied grooved on either or both surfaces to remove imperfections and are produced in the following conditions and surface finishes:

Hot rolled—Scale not removed and plate not heat treated. Not recommended for final use in this condition.

Hot rolled, annealed, or heat treated—Scale not removed. Use in this condition generally confined to heat-resisting applications. Scale impairs corrosion resistance.

Hot rolled, annealed or heat treated, blast cleaned or pickled. Condition and finish preferred for corrosion-resistant and heat-resistant applications. Normally specified where moderate forming is followed by polishing.

Hot rolled, annealed or heat treated, surface cleaned and polished. Polish finish is generally No. 4. Specified where additional finishing or polishing is not required after fabrication. Welds and minor surface damage are hand-blended on the finished article.

Cold-Rolled Strip

Strip is supplied in coils or in cut lengths and can be stretcher leveled or roller leveled for improved flatness. Strip stock is produced in dimensions under 3/16 in. thick and under 24 in. wide. Available edge finishes are: No. 1 edge, rolled round or square; No. 3 edge, produced by slitting; and No. 5 edge, produced by rolling square or filing after slitting.

Cold-rolled strip is supplied in two special finishes. No. 1, similar to a No. 2D sheet finish, is obtained by cold rolling, annealing, and pickling and is generally specified for severely drawn or formed parts. No. 2, comparable to a No. 2B sheet finish, is obtained by a light cold-roll pass of strip with No. 1 finish through highly polished rolls. This is a general-purpose finish used on such items as trim and tableware.

All types of stainless steel strip can be obtained in either the soft annealed or annealed and skin-passed tempers. The austenitic grades can be produced in the fine tempers and with varied mechanical properties. Some of the martensitic types can be furnished hardened and tempered. Where required, cold rolling to produce a No. 2 finish serves to alleviate stretcher strains in the ferritic types.

Bars

Cold-finished bars can be obtained as rounds, squares, hexagons, and octagons. Half-round, flat, triangular, or other special shapes are available to eliminate expensive machining from standard bars.

Bars are normally processed in straight lengths. Small-diameter bars in coil form are available for fabrication in automatic machinery to take advantage of continuous lengths. These conditions and surface finishes may be specified:

1. **Forging Stock:**
   - a. Scale not removed (excluding spot conditioning).
   - b. Rough turned (round bars only). Not generally available in high-hardening martensitic types.
   - c. Pickled or blast cleaned and pickled.
2. **Annealed or otherwise heat treated:**
   - a. Scale not removed (excluding spot conditioning).
   - b. Rough turned (round bars only).
   - c. Pickled or blast cleaned and pickled.
   - d. Cold drawn or cold rolled.
   - e. Centerless ground (round bars only).
   - f. Polished (round bars only).
3. **Annealed and cold worked to high tensile strength** (austenitic types only):
   - d. Cold drawn or cold rolled.
   - e. Centerless ground (round bars only).
   - f. Polished (round bars only).

Tensile strength of austenitic-grade bars can be materially increased by cold drawing or cold rolling. Cold working is especially useful for stressed members where maximum strength is desirable. Motor shafts and parts subject to constant and severe wear are best made from martensitic steel bars provided corrosion resistance of the grade selected is adequate for end use. These steels can be supplied in the heat treated, or hardened and tempered, condition.

Wire

Stainless-steel wire is specified by names derived from the applications for which they are designed.

Free-Machining Stock—For improved machinability, especially in automatic screw machine work. Types 303, 303Se, 416, 416Se, 430FSe are used for screws, bolts, shafts, and similar parts.

Cold-Heading Wire—For cold heading and cold-forging operations. Where severe upsetting is required, Types 305, 430, and 410 are best.

Spring Wire—For expansion and compression springs. Types 302 and 304 are generally specified for spring wire. Type 316 provides improved corrosion resistance.

Rope Wire—For ropes, cables, and cords for aircraft control cables, slings, anchor cables, and similar applications. Generally made from Types 302 or 304. Where improved corrosion resistance is required, Type 316 is specified.

Weaving Wire—For woven screens used in sand and gravel pits, paper mills, and chemical plants, for example. Most types of stainless steel are furnished in weaving wire.

Armature-Binding Wire—Produced in Types 302 or 304.

Slide-Forming Wire—For use on slide-forming machines to produce paper clips and similar parts. Although produced in all types of stainless steel, Types 302, 304, 316, 410, and 430 are most frequently used.

Wool Wire—For cutting or shredding wool. Wool wire is usually made from Type 430.

Reed Wire—For making dents for reeds, used in weaving textiles, and in other products. Usually made from Type 430.

Lashing Wire—For lashing aerial conductor cables to supporting strands. Generally made from Type 430.

Cotter-Pin Wire—Available in most standard types of stainless steel.

Special shapes, finishes, and coatings are frequently required for these wires to fulfil the end uses described. In addition to round wire, such sections as half round, half oval, oval, square, rectangular, hexagonal, octagonal, and triangular are available.

Through annealing, or by regulating the number of draws, wire can be produced in the following tempers:

Annealed Temper—Dead soft, essential for cold-heading wire, lashing wire, and for some applications of weaving wire.

Soft Temper—Drawn once after final annealing. For cotter pin wire to prevent spring-back.

Intermediate Temper—Drawn one or more times after final annealing. For reed wire, and rope wire to provide a specified minimum tensile strength or hardness.

Spring Temper—Drawn several times to produce spring wire with high tensile strengths.

These various wire-drawing methods allow for special finishes or coatings to be produced on the wire. An oil or grease-drawn finish is a special bright finish obtained by using lubricant in the die box. This final finish is used on such parts as racks and handles. A diamond-drawn finish, extremely bright, is obtained by wet drawing of fine sizes of wire at reduced speeds with liquid lubricants.

Special metallic or oxide coatings can be furnished on wire by dry drawing. The following coated finishes can be obtained:

Copper coating—To provide lubrication for spring coiling or cold-heading operations.

Tinned wire—To facilitate soldering, as with armature-binding wire.

Lead coating—As a lubricant for spring coiling operations.

Tubular Products

Tubing can be obtained in sizes from a few thousandths to 6⅝ in. diameter. Tubes are usually cold finished by a cold-reduction die and mandrel or by tube reducing or swaging. Closer dimensional tolerances, special shapes, smoother surfaces, and varied mechanical properties can be obtained by these methods.

Stainless tubing may also be specified as ground or ground and polished on both inside and outside surfaces. Polished surfaces are specified in terms of grit number: 80 grit, 120 grit, 180 grit, or 320 grit. Generally, it is not feasible to polish inside surfaces of tubes with an ID of less than ¾-in.

Except when extruded, special hollow shapes, and square and rectangular shapes are usually first produced as round sections. They can be ground and polished in this condition, and then drawn or rolled to the shape required.

Clad Stainless

Stainless-clad steel plates, sheets, and strip are made with a layer of stainless steel integrally bonded to one or both sides of a carbon or low-alloy steel backing plate. Cladding thickness ranges from 5 to 50 per cent composite plate thickness, but is usually at least 0.030 in. Cladding permits high corrosion and oxidation resistance and other advantages of stainless steel to be obtained economically. Copper or aluminum can also be combined with stainless steel for good heat conductivity.

The tremendous adhesion strength of the bond is obtained by the weld formed over the entire interface by pressure and high temperature, generally produced by mill rolling. Clad steel can be stretcher leveled for better flatness and furnished with polished or unpolished finishes.

Extruded Shapes

The extrusion process is the latest method for converting stainless steel ingots or billets to shaped bar stock or tubing.* Cross sections which can be extruded include solid, semihollow, hollow, and tapered shapes. Stepped extruded parts are possible by combining extrusion and forging operations. Cold drawing after extruding produces parts to extremely close tolerances ,representing finished work in most cases. A variety of special sections, not available in other mill forms, can be extruded in long sections and sliced to length.

Designers can obtain certain extruded shapes in alloys which cannot be rolled or pierced. Reduction or elimination of machining and joining operations, and economy for small production runs are characteristic benefits of extruding.

Availability of Warehouse Material

The most common grades, sizes, and shapes of stainless steel likely to be readily available are:

Plates—Usually hot rolled, annealed, pickled finish. Some sizes cold rolled.

Sheets—Gages 28 to 10 inclusive, in Grades 302, 304, and 316. Sheet sizes range from 24 to 48 in. wide and from 96 to 120 in. long, in polished and unpolished finishes.

Bars—Types 304 and 316 in thicknesses from 3/16 to 2½ in.

Tubes and Pipe—Seamless and welded, Types 304, 316, and 347 in diameters to 8 in. In addition, special stainless-steel welding rod fittings, nuts, bolts, cotter pins, screws, washers, and other articles are generally available.

Semiprocessed Products and Components

Many rolled stainless-steel parts may be obtained without incurring tooling charges since special rolls are sometimes on hand. Other semiprocessed materials generally available include: Moldings and trim, perforated and expanded metals, and wire mesh.

Also available are products of sintered stainless-steel powder and textured stainless steel.

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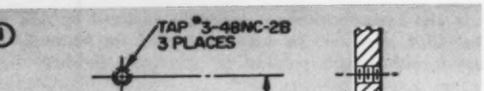
*R. E. Paret—"How to Design Stainless Steel Extrusions," MACHINE DESIGN, January 8, 1959, Part 1, p. 114; January 22, 1959, Part 2, p. 118.

Tips and Techniques

Standard Gear-Center Assembly Drawings

①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XXX
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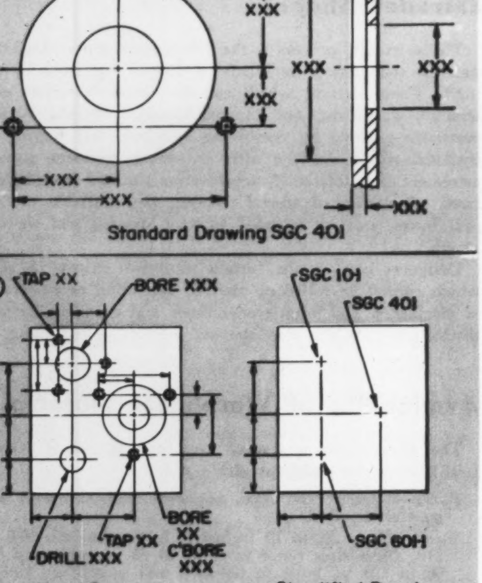
XXX

Standard Drawing SGC 401

②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BORE XXX
DRILL XXX
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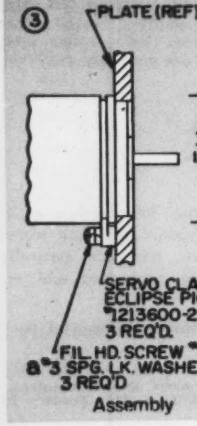
BORE XX
C'BORE XXX
SGC 101
SGC 401
SGC 60H

Usual Drawing

Simplified Drawing

③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ECLIPSE PIONEER
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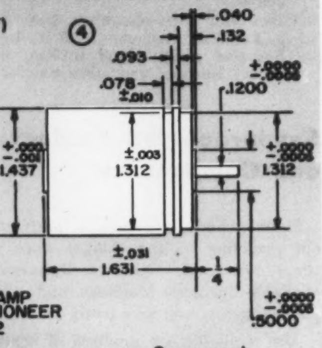
& #3 SPG. LK. WASHER
3 REQ'D

Assembly

④


.040
.132
.093
.078 ±.010
.1200 +.0000 −.0005
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±.003 1.312
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±.031 1.631
1/4
+.0000 −.0005 .5000

Component Outline

Designing servomechanism gear-train assemblies that are common in commercial and military products involves time for layout and detail drafting, and checking. Additional time is consumed in the shop to position a particular set of holes in the maze of holes that usually exists on a set of gear plates.

Considerable time can be saved by preparing a set of standard gear-center drawings for use with all components that are repetitively used. These drawings are of three basic types, and the choice of type depends upon the degree of standardization desired.

Type 1: Drawings of this type show only the required holes for mounting a particular component. Two or more concentric holes and counterbores with three or four tapped holes for clamps are usually involved. The standard drawing is similar to Fig. 1, with an appropriate coding number assigned.

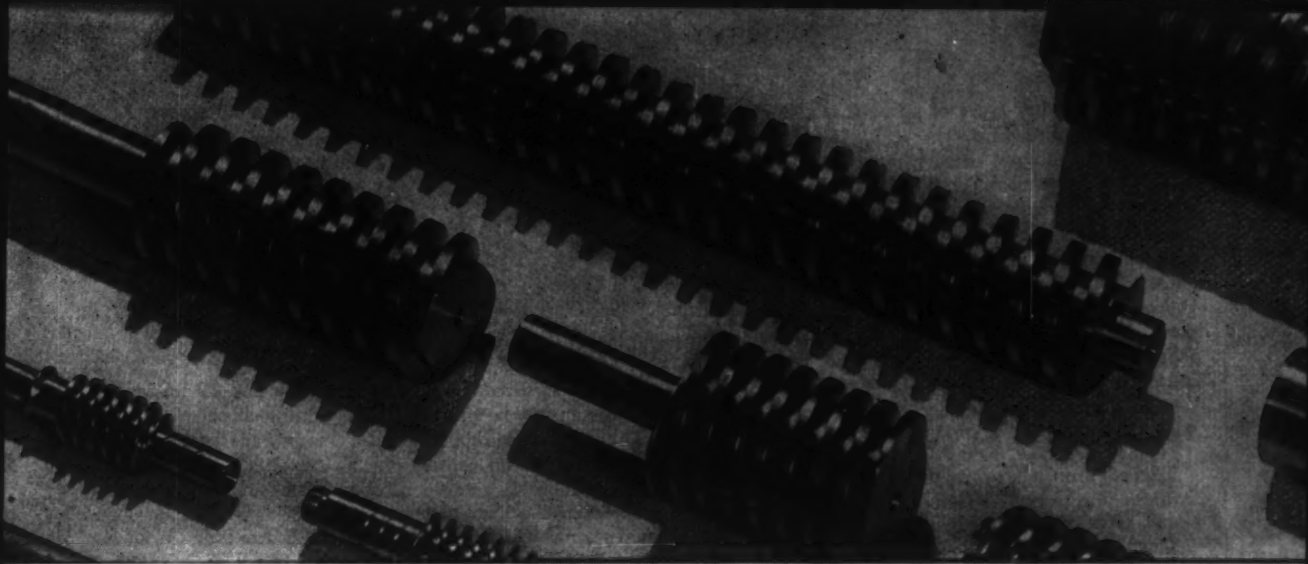
In actual use, the set of holes, Fig. 2, is identified on a plate drawing by a center location and the standard hole configuration number. The shop has an identical set of standard gear-center drawings which are used for hole information.

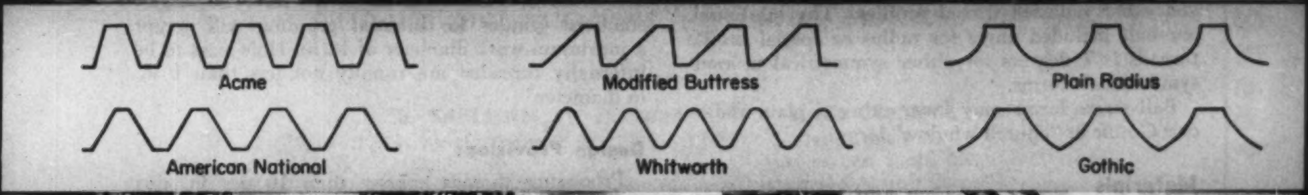
Type 2: Additional advantages are realized by incorporating the assembly of the component to the plate on the standard drawing. Thus the standards are used on assembly drawings, Fig. 3, as well as the detailed plate drawings.

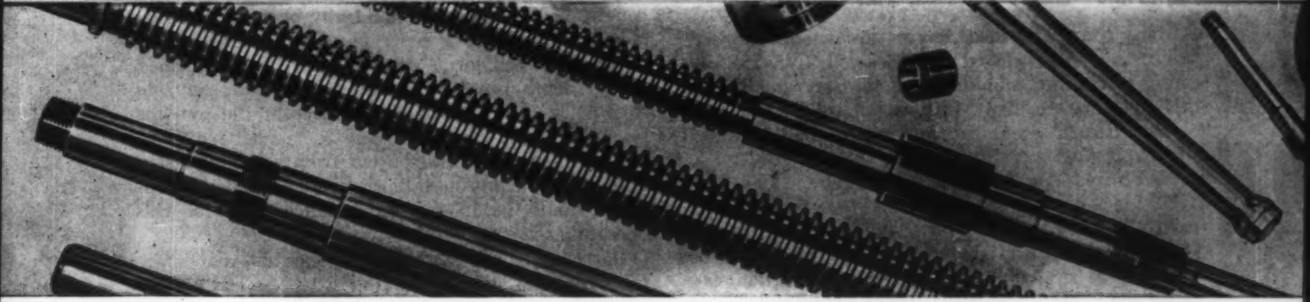
The same standard number is used for either the assembly or detail drawing and provides a quick means of checking for the correct location of components.

Type 3: Drawings of this type use Type 2 drawings with an outline dimensional drawing of the component added.

By incorporating the component outline dimensions, the gear-center assembly drawing contains all pertinent information on the component from the manufacturer's part number through to the mounting of the component on a gear-train assembly. This reduces to a minimum the number of drafting errors that result from correlating information from miscellaneous catalogs and drawings. Fig. 4 shows an outline drawing of the component. —Frank William Wood, *design engineer, Servonics Inc., Alexandria, Va.*







Designing for Thread Grinding

. . . to produce precision parts with fine surface finish from even the hardest metals

GILBERT D. STEWART
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Machinery Div.
Ex-Cell-O Corp.
Detroit, Mich.

THREAD grinding is a precision method of producing a given thread form on a part through cutting contact between the part and a suitably shaped grinding wheel.

This process is principally used on material in which it is impractical to produce threads by rolling, chasing, or milling. Ordinarily, thread grinding is most advantageous in material harder than Rockwell C27. Other methods of forming threads in material harder than Rockwell C36 are usually altogether impractical. Certain very soft materials which do not machine well may also be best threaded by grinding.

Fine surface finish and extreme lead accuracy are characteristics of thread grinding, and parts for precision work often can not be produced by any other method. For many types of parts, it is also the fastest means of threading.

Thread grinding is extensively used in the manufacture of steering mechanisms, lead screws, feed screws, and worms. Since the process does not tear the thread form at the root diameter as most cutting-tool methods do, it is frequently specified for highly stressed parts to reduce the possibility of fatigue cracks which may start from almost microscopic imperfections. Such highly stressed parts subject to fatigue failure are found in tank, gun, and aircraft components.

Thread Forms

Thread profiles are produced in numerous forms. Straight-line forms include Acme, American National, or modified buttress threads.

Curved surfaces are represented by Whitworth and other radiused thread profiles. The minimum, one-half included angle for radius or special profile threads is 7 degrees for either symmetrical or nonsymmetrical forms.

Ball-screw forms may have either a plain radius or a Gothic or "church window" form.

Materials

Many precision lead screws are made of SAE 6150 steel, heat-treated to Rockwell C45-55, because machining stability and wearing quality of this steel are excellent. Stresses set up by grinding coarse threads are corrected by normalizing and stress-relieving operations.

Carburized and hardened materials such as SAE 3120, 3118, or 8620 steels are often used for threaded parts. However, with parts having long thread length, such as lead screws, lead distortion can be incurred in heat treating. Excessive distortion can cause the grinding wheel to break through one side of the hardened case during finish grinding.

Cold-rolled materials such as Stressproof and SAE 1117 and 1137 are acceptable for soft parts. Better grinding conditions and stability, however, are obtained by using the former material.

If stainless steel is to be used, the 400 series is preferred for lead screws of 8 pitch and coarser. Material should be heat-treated to a minimum of Rockwell C35 for best machining.

Table 1—Standard Pitches for External Threads*

Thread Type	Pitch (tpi)
Unified and American threads	
Finish grinding from solid blank	10 to 120
Precut form for lead accuracy	up to 10
Worms and Acme threads	1 to 20
Whitworth threads	2 to 72

*Tool, high-speed, and alloy steels.

Table 2—Standard Pitches for Internal Threads

Thread Type	Pitch (tpi)
American National threads, in tool and alloy steels	4 to 32
Acme threads, in hardened tool and alloy steels, ground after precutting	2 to 20

Thread Pitches

Common external thread pitches for certain steels are given in Table 1. A corresponding list for internal threads is shown in Table 2.

Size of Parts

External threads up to 120 in. long and 12 in. in diameter can be ground in one setting of the work. The largest standard grinder mounts parts up to 144 in. between centers and swings 19 in. over the work table. There is no limitation on minimum size of the workpiece.

Internal threads can be up to 5 in. long in a maximum internal diameter of 16 in. The largest standard grinder for internal grinding will accept a maximum work diameter of 18 in. Hole sizes to be internally threaded are usually not less than 1 in. in diameter.

Design Provisions

Processing threads coarser than 10 per in. can usually be done more economically by rough threading the blanks in a separate operation. All worm or Acme thread forms should be precut to finished thread depth plus approximately 0.010 in. per side to provide grinding-wheel clearance at the root for finish grinding.

External threads can be cut from solid blanks in both soft and through-hard steels. Outside diameters should be in the semifinished state for this operation.

Parts with external threads should have space for overtravel of the grinding wheel unless incomplete threads can be tolerated. Provision should also be made for wheel clearance near shoulders to prevent part damage.

Recommended practice for internal threads is to provide an undercut at the rear of the thread section to allow for grinding-wheel clearance.

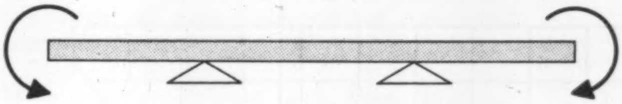
To permit proper location of the workpiece in the machine, small parts usually are provided with good centers or a diameter for chucking. On long screws it is often necessary to hold a close tolerance on the major diameter so that bushing-type steady rests can be used.

Thread Tolerances

Thread grinders are manufactured to hold thread lead tolerance within ±0.0002 in. per in. and cumulative error within 0.0005 in. in any foot. On pitch diameters, ±0.0002 in. tolerance can be held. Closer tolerances can be maintained under proper conditions.

As a guide to basic screw thread tolerances, accepted standards are found in the U. S. Dept. of Commerce manual, *National Bureau of Standards Handbook*, H28, 1944. Special tolerances may be permitted where the intent is to produce a close running fit between the nut and the screw.

Minimizing Maximum Beam Moments



Charts and equations for finding best location of supports

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Design Weight Engineer
Calif. Div.
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MAXIMUM bending moment in a simply supported beam is a function of the number and location of beam supports. When the support arrangement is designed so that maximum moment is a minimum, required "bending material" of the beam is a minimum and efficiency of the beam structure is a maximum.

Nomenclature

c = Overhang or end span of beam, in.
d = Intermediate span of beam, in.
L = Beam length, in.
M = Bending moment, lb-in.
P = Concentrated load, lb
R = Reaction, lb
w = Uniformly distributed load, lb per in.

This article presents equations and charts for finding optimum location of supports in simply supported beam structures where weight is critical. Practices outlined here find ready application in design of structural elements for aircraft and missiles.

Two Supports—Uniform Load: Bending moments in a uniformly loaded beam with two symmetrical supports, Fig. 1, can be determined from (see Nomenclature)

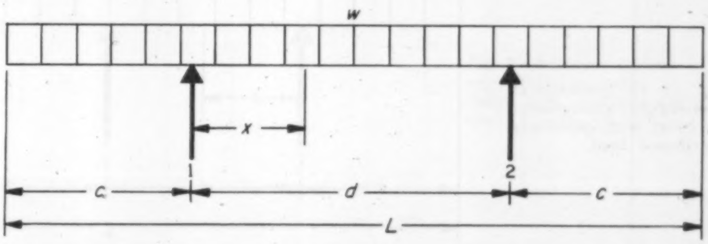
$$M_1 = M_2 = \frac{wc^2}{2} \tag{1}$$

$$M_x = \frac{w[(c + x)^2 - Lx]}{2} \tag{2}$$

where M_1 and M_2 are moments at the supports.

Maximum moment M_{max} for the beam section be-

Fig. 1—Symmetrical two-support arrangement for beam with uniformly distributed load.



tween supports is developed at the center of the beam,

$$M_{max} = w\left(\frac{Lc}{2} - \frac{L^2}{8}\right) \qquad (3)$$

Effect of support location on bending moments is shown in Fig. 2. When beam weight is critical, optimum position of the supports corresponds to the condition where bending moments at the supports and the center of the beam are equal. Maximum efficiency of the beam material in bending is obtained with this arrangement. Setting Equations 1 and 3 equal and solving for c gives

$$c = 0.207\,L \qquad (4)$$

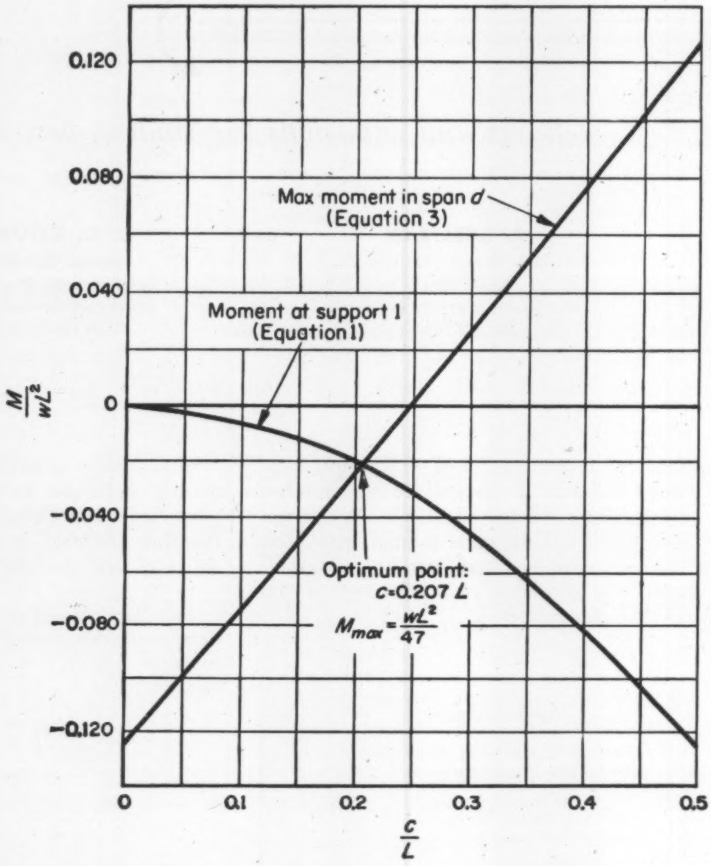


Fig. 2—Effect of support location on principal bending moments in beam structure shown in Fig. 1.

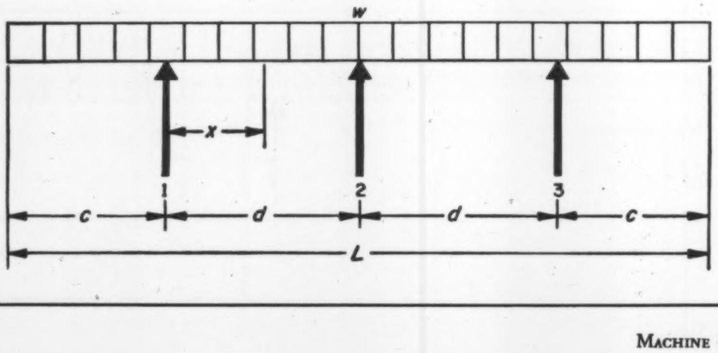


Fig. 3 — Symmetrical three-support arrangement for beam with uniformly distributed load.

Maximum moment for this condition is

$$M_{max} = \frac{wL^2}{47} \tag{5}$$

Maximum moment when the supports are at the beam ends ($c = 0$) is

$$M_{max} = \frac{wL^2}{8} \tag{6}$$

As shown by comparison of Equations 5 and 6, a beam with supports at the optimum position is approximately six times more efficient than one supported at its ends.

Three Supports—Uniform Load: When a beam with uniform loading is supported at three points, Fig. 3, it can be shown that distance between supports should be equal for minimum weight. Such symmetry will be assumed here. Optimum relationship between beam overhang and support spacing will now be determined.

Three-moment equation for continuous beams is

$$M_1 d + 4M_2 d + M_3 d = \frac{wd^3}{2} \tag{7}$$

Since support arrangement and moment distribution are symmetrical, only the left half of the beam will be considered.

Moment M_1 can be determined from Equation 1. For the span between supports 1 and 2,

$$M_x = \frac{w(c + x)^2}{2} - R_1 x \tag{8}$$

Location and magnitude of maximum moment in this span are given by

$$x = \frac{3c^2}{4d} + \frac{3d}{8} \tag{9}$$

$$M_{x,max} = w\left(\frac{7c^2}{32} - \frac{9c^4}{32d^2} - \frac{9d^2}{128}\right) \tag{10}$$

Maximum moment in the overhang section of the beam occurs at support 1 and is an increasing

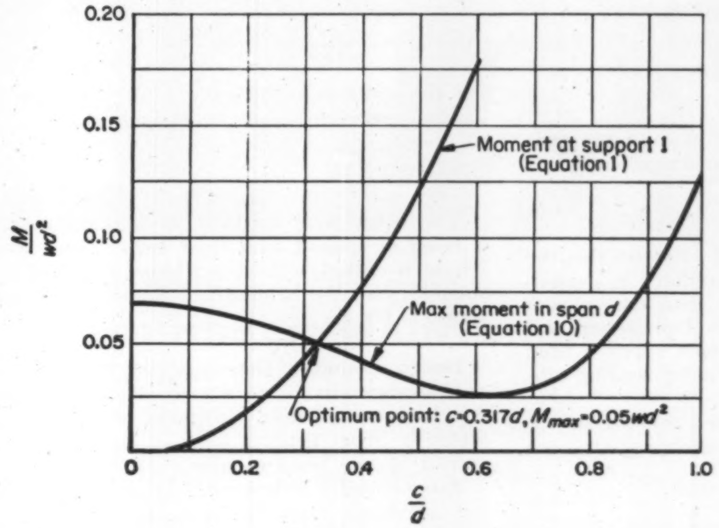


Fig. 4—Effect of support location on principal bending moments in beam structure in Fig. 3.

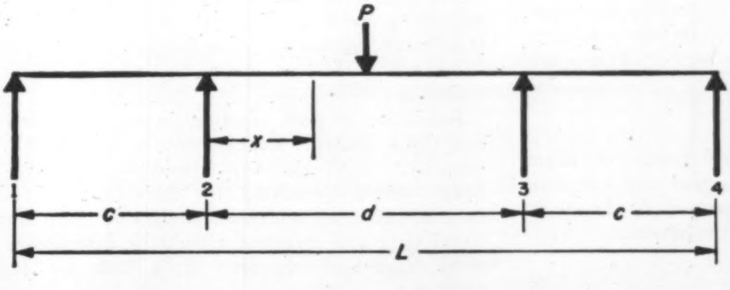


Fig. 5—Symmetrical four-support arrangement for beam with concentrated load at center of span.

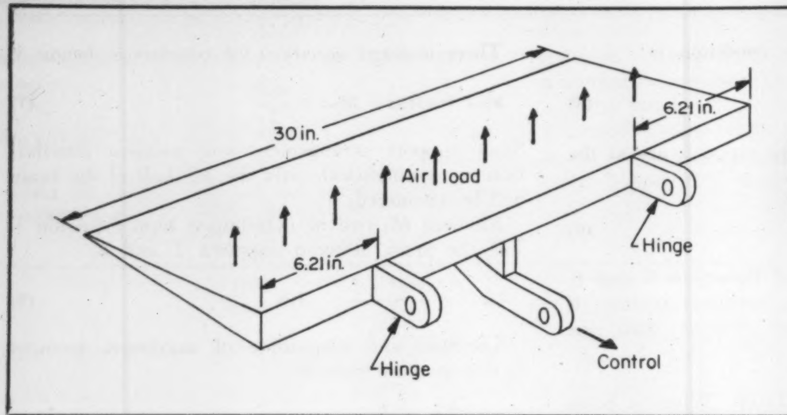


Fig. 6—Aileron tab with two support hinges which are located for optimum distribution of bending moment on structure.

function of c. In the span between supports 1 and 2, maximum moment decreases initially, reaches a minimum value, and then increases as c increases. Relationship of these bending moments to support location is shown in Fig. 4.

Optimum value of c is determined by setting Equations 1 and 10 equal and solving for c;

$$c = 0.317d = 0.12L \tag{11}$$

Corresponding bending moment is

$$M_{max} = 0.05wd^2 = 0.00685wL^2 \tag{12}$$

If supports 1 and 3 are located at the beam ends ($c = 0$), maximum moment from Equation 10 is

$$M_{max} = -\frac{9wd^2}{128} = -0.0175\,wL^2 \tag{13}$$

Comparison of Equations 12 and 13 shows that the beam with optimum length of overhang is approximately 2.5 times more efficient than one without overhang. In addition, based on Equations 5 and 13, increasing the number of beam supports from two to three increases the maximum bending efficiency by a factor of three.

The point at which maximum moment in the span between supports 1 and 2 reaches a minimum value, Fig. 4, is

$$c = 0.62\,d \tag{14}$$

Moment at this point is

$$M_{max} = -\frac{wd^2}{36} = -0.00264\,w\,L^2 \tag{15}$$

A large overhang is required to provide this minimum value of maximum moment in span *d*. Corresponding bending moment at support 1 is much greater than that obtained with the optimum value of c, Equation 11.

Four Supports — Concentrated Load: A beam with a concentrated load at its center and four supports in a symmetrical arrangement is shown in Fig. 5. From the three moment equation,

$$M_1c + 2M_2(c + d) + M_3d = \frac{3Pd^2}{8} \tag{16}$$

By symmetry, moment $M_2 = M_3$. Assuming $M_1 = 0$ gives

$$M_2 = \frac{3Pd^2}{8(3d + 2c)} \tag{17}$$

Maximum moment in the center span is

$$M_{x,\,max} = \frac{3Pd^2}{8(3d + 2c)} - \frac{Pd}{4} \tag{18}$$

For the optimum condition, $c = 0$. Corresponding maximum moment in the center span is

$$M_{max} = -\frac{Pd}{8} \tag{19}$$

This equation is the same as that obtained for a beam of span *d* with fixed ends. Thus, where weight is critical, a fixed-end beam would be more suitable than the symmetrical four-support design shown in Fig. 5.

Design Example: Determine the optimum support arrangement for an aircraft aileron tab, Fig. 6. Air load is uniformly distributed along tab span which is 30 in. Bending loads in tab structure are carried by one beam member.

Assume load is to be carried by two hinges which act as simple supports. From Equation 4, $c = 0.207(30) = 6.21$ in. which is the distance from each end of the tab to a hinge support. From Equation 5, $M_{max} = w(30)^2/47 = 19.2w$.

For a three-support arrangement (Fig. 3), Equation 11 gives $c = 0.12(30) = 3.6$ in. Distance from outer support to center support is $d = [30 - 2(3.6)]/2 = 11.4$ in. From Equation 12, $M_{max} = 0.05w(11.4)^2 = 6.5w$.

Reduction in peak bending moment provided by the three support arrangement is $(100)(19.2 - 6.5)/19.2 = 67$ per cent. However, reduction in beam weight permitted by three-support design may be offset by additional weight of third hinge. Total weight of structure should be determined for both support arrangements as a basis for design decision.

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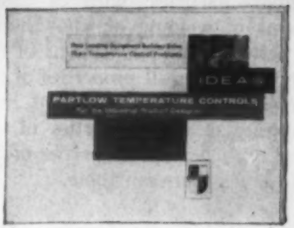

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COATINGS produced by the metallizing process differ considerably both chemically and physically from the original wire used to produce the metal spray. A sprayed metal deposit consists of many individual particles with a small amount of welding or alloy bonding between minute portions of the particles. Over-all properties of the sprayed metal must, therefore, be a composite of the properties of the metal particles and properties of the oxide layers between them.

Metallized Zinc for Corrosion Protection: Galvanizing is specified on many types of equipment where paint would fail rapidly. However, galvanizing is limited because of tank sizes and thickness of metal which may be applied by this method. Application of metallized zinc is not limited in such respects. Any size structure can be so treated before or after fabrication regardless of location, and any thickness of zinc may be applied.

The electrolytic potential of sprayed zinc is identical to that of hot-dipped galvanizing and thus provides electrolytic protection to bare areas. In salt or industrial atmospheres, treating or sealing of the metallized zinc coating with organic materials is usually recommended. Coatings treated in this manner will be dissipated at a rate of from 0.0001 to 0.0006 in. per year.

Spray-metallized zinc coatings have a certain degree of inherent porosity. Experience has shown that this porosity is not detrimental to the protective properties of the coating compared to a nonporous coating containing the same quantity of zinc per unit area.

During the last few years, the scope of the metallizing process has been broadened considerably by the use of sealing treatments designed to fill the pores of sprayed metals. In the corrosion field, vinyls, chlorinated rubbers, phenolics, and various other organic materials have proven useful for sealing spray-metallized zinc coatings.

Metallized Zinc as a Paint Base: During the last ten years, emphasis in the metallizing industry has been on combination coatings which consist of a layer of sprayed metal sealed or coated with organic materials such as vinyls, chlorinated rubbers, phenolics, and silicones. These coatings are generally referred to as metallized system coatings. Sprayed metal, 10 mils thick or more, offers excellent protection against many severe corrosive environments. Metal coatings of these thicknesses, however, are relatively expensive compared with paint coatings.

The difference between thick and thin metal coatings is quantitative, but there are a number of qualitative differences as well. Thick coatings are thought of as the primary protective barrier whether or not paints and organic sealers are used. The cost is relatively high, and service requirements must justify the expense. Where thin coatings (2 to 4 mils) are used as a base or preparation for paint, the story is quite different. The primary protection in this case is from the paint and the primary purpose of the sprayed metal is to enhance and prolong properties of the paint film. Coatings of this kind are quite inexpensive and, in many cases, prove less costly than paint alone.

Sprayed zinc coatings are porous and, unlike galvanized surfaces, offer an excellent anchor for paint. In spite of the porosity, and even when no paint is applied, sprayed zinc provides long-term protection to steel. This is true for two reasons:

1. These metals are anodic to steel and provide cathodic protection even at small voids in the coatings.
2. Sprayed metal coatings become less permeable with time when conditions of environment favor formation of insoluble salts and oxides within the pores. The protective life is, however, related to thickness, and thickness is related to cost. Where thin coatings are painted over, pores are filled and very little, if any, bare metal is exposed to corrosive environment.

With a clean steel surface, metal spraying is an intermediate step which may be considered as part of the preparation for painting. At this stage, a thin coat of zinc is quite inexpensive. One of the biggest cost factors for a heavy industrial

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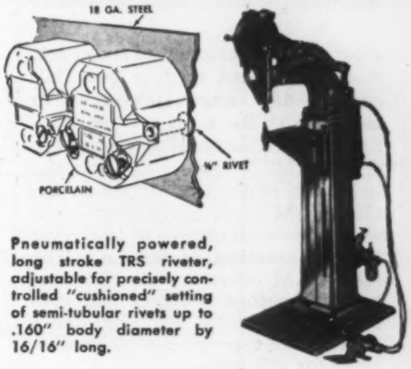

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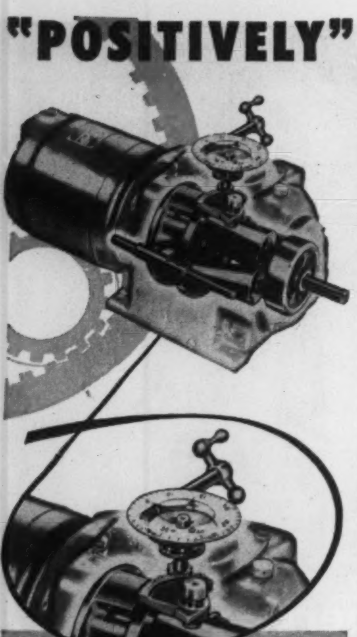

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metallizing coating is the grit-blast operation required for preparation. Where thin coatings such as 2 to 4 mils are used, particularly for zinc, requirements of the blast job are considerably reduced. In fact, a first-class blast job for paint application is often sufficient, and the zinc may be applied without additional blasting costs. In such cases, the benefit derived from the sprayed metal base far outweighs cost in extending the life of the paint coating.

A relatively thin coating of metallized zinc provides far stronger adhesion than can be obtained by any other method. Such a coating effectively prevents rusting at the interface, which is the most common cause of paint failure. In the long run, the main consideration is maximum protection per dollar.

Paints and primers used must be compatible with the sprayed metal, and some materials compounded for steel or galvanized zinc are not satisfactory over a metallized base. In particular, sprayed zinc should never be confused with galvanized zinc. On galvanized surfaces strong acid primers sometimes are used which actually attack the galvanized surface and etch it. Sprayed zinc on the other hand offers a natural bond for paint. Primers should be used not to etch the coating but as inhibitors. For instance, wash-coat primers containing phosphoric acid are frequently recommended on sprayed zinc for inhibitive purposes, but the acid content must not exceed 4 per cent. Some primers for galvanized surfaces have acid contents up to about 16 per cent and these would be death to sprayed metal.

When applying paints directly to sprayed metal, it is advisable to thin down the first one or two coats to obtain better penetration into the base. For the best job, the base coat should be unpigmented and diluted with three parts of thinner to one part of paint. The second coat should be unpigmented and diluted one part of thinner to one part of paint. This is followed by full-strength pigmented material in the desired number of coats. The thinned paint vehicle, however, is not a substitute for inhibitive primer which should always be used where severe moisture conditions

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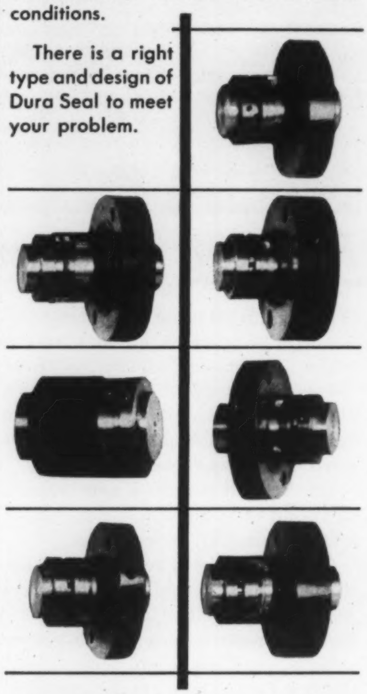

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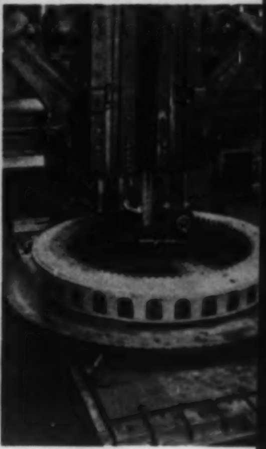

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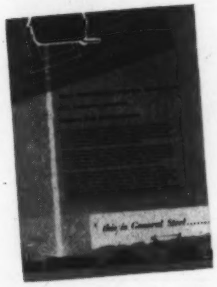

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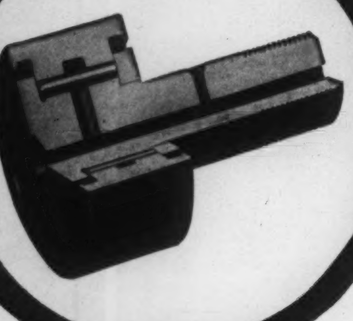

McGILL sealed CAMROL® bearings protect roller follower efficiency — prelubricated to reduce maintenance

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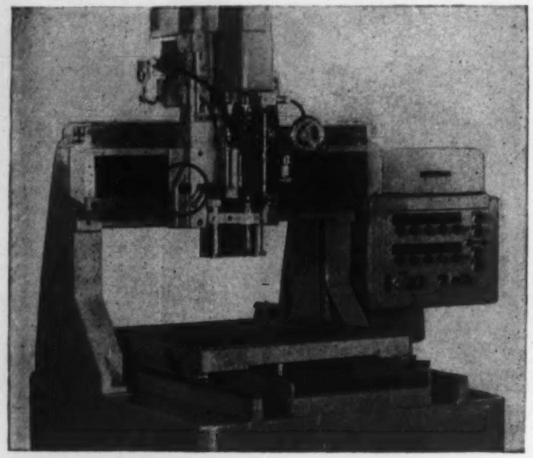
The sealed construction with a channeled grease reservoir in the outer race bore eliminates need for frequent relubrication. Maintenance is reduced and can be eliminated in inaccessible mountings. Specify standard bearings and avoid building up followers with extra seals.



Sealed CAMROL bearings as table and crosshead rollers in tape-controlled Hillyer drilling machine

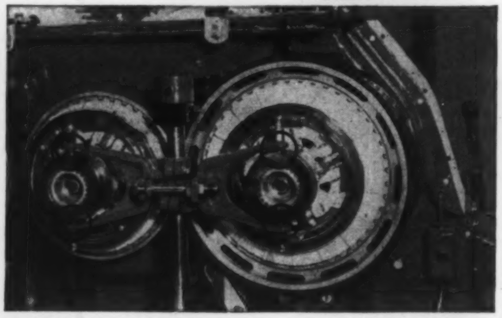
CAMROL bearings provide smooth, accurate motion as load carrying rollers for table and crosshead motion of this tape-controlled, precision drilling machine manufactured by HILLYER CORPORATION. Use of these bearings has simplified construction and improved accuracy. They have eliminated the manufacture of shaft and retainer assemblies and increased load capacities. The corrosion resistant finish has also eliminated the need for plating bearings. Ball bearings formerly used cracked under the same loads. Operating speeds are 400 RPM and loads are 2000 pounds. The bearings are prelubricated and sealed to keep maintenance at a minimum.

Sealed CAMROL bearings replace bronze rings in shovel clutches

UNIT CRANE & SHOVEL CORPORATION is using SCF SEALED CAMROL bearings in clutch shifter yokes in their ½ and ¾ yard power cranes and shovels and Model 360 MARINER 30-ton cranes. Shown is a closeup of two of the five clutches which control the hoist drum and the hold drum and various actions of the machines. The bronze collars formerly used were higher in initial cost than the CAMROL bearings. Their use also required considerable machining and the addition of component parts such as bolts, spacers, etc.

The CAMROL bearings in this application promise better, more accurate control than the bronze shifter rings which tend to become "sloppy" with wear.

The integral seal feature of the bearings protects their performance under field conditions and reduces relubrication requirements.



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precision needle roller bearings

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McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

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are prevalent.

Metallized Aluminum for Corrosion Protection: Various systems have been developed to meet different corrosive conditions. These systems generally comprise pure metallic zinc or aluminum coatings applied by metallizing and treated with special organic materials. The finished coating has the same color and appearance as aluminum paint. Such systems are recommended for the protection of iron and steel against corrosion in the following atmospheres:

1. Industrial atmospheres encountered in large cities or around plant properties where smoke and chemical fumes are present.
2. Salt atmospheres encountered on the coast or to one mile inland. Parts not actually subject to salt spray.
3. Humid atmospheres encountered in the South Atlantic and Gulf States.

The combination of a pure metallized aluminum and a vinyl treatment provides extremely long life without necessity of reapplication such as normally required with painting. This gives the lowest yearly cost protection against corrosion that can be obtained under conditions listed. The metallized aluminum has a surface porosity which provides the best possible base for subsequent coating. Material used for the vinyl treatment seals the aluminum and forms a corrosion-resistant film. Since it is applied to a metallized aluminum coating, it is firmly bonded and will not blister.

The seal coat gradually weathers away over a period of years, leaving the metallized aluminum to protect the steel. Oxides of aluminum form on this surface and dissipate very slowly. Thus, the heavy aluminum metal coating provides years of protection under severe corrosive conditions even without the seal coating. However, by reapplication of seal coatings at long intervals, it is possible to maintain the full thickness of the metallized aluminum and prevent corrosion on the steel for any desired period. Reapplication is inexpensive because heavy cleaning operations are unnecessary. There is no rust or scale to remove. Corrosion maintenance costs can, therefore, be cut by at least 50 per cent even on relatively short-life structures. In original

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JACKS

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They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66v.

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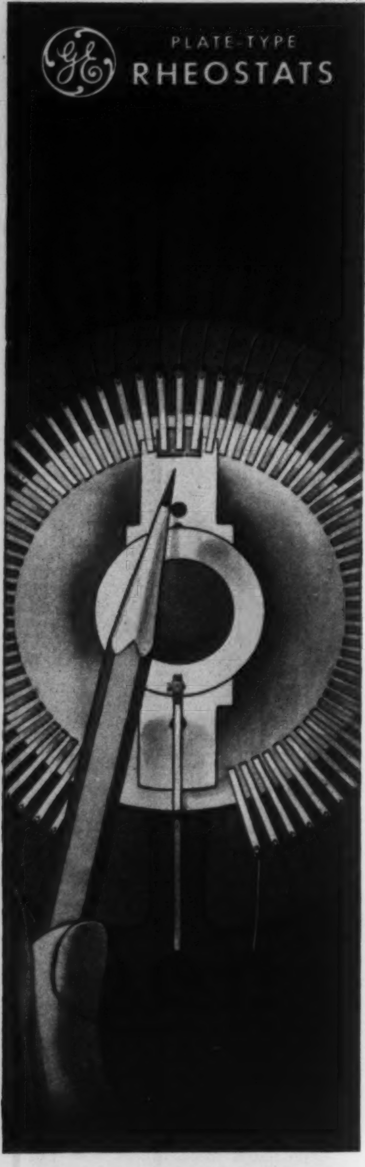

LESS CONTACT WEAR WITH G-E RHEOSTATS

Less contact wear means longer rheostat operating life, and General Electric rheostats feature special wear-resistant contact segments. The moving contact rides on these segments—not on the resistance element. For full details on G-E long-life plate rheostats, follow reader service instructions below. General Electric Company, Roanoke, Virginia. 784-22

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design, the safety factor for corrosion can be substantially cut down or eliminated and capital investment reduced.

Some of the sealing treatments included in various sprayed metal systems do not specify a primer. Tests and field experience have shown that a primer is not essential with these particular systems, if the work is done properly under ideal conditions. However, it is often desirable to use a primer with these systems and in some instances it may be an absolute necessity.

In normal paint practice, a primer has one or more of the following functions:

1. Improves initial adhesion.
2. Inhibits corrosion.
3. Passivates the surface.
4. Displaces, or is compatible with, small amounts of moisture.

When sealers are applied to sprayed metal, initial adhesion is no problem. The nature of the surface is such that any sealer or paint which is chemically compatible with the sprayed metal will adhere perfectly. Some of the systems developed for atmospheric service may be used in unusually wet locations. If the surface is damp more than about 25 per cent of the time, the environment may be classified as wet. Inhibitors of the chromate type used in a primer tend to reduce the aggressiveness of moisture which finds its way through the top coats. So a primer should be used where top coats are applied over sprayed metal and exposed to a wet environment. Passivation supplements inhibition and serves the same purpose but in a somewhat different manner. Freshly sprayed metal is in a fairly active state. The thin phosphate film formed by the primer renders the metal less active and so is desirable where a wet environment is involved.

Protection at Elevated Temperatures: Aluminum metallizing for protecting steel at elevated temperatures has many advantages. Metallizing is the only aluminum coating method where the process can be carried to the work. Coatings can be built up to any desired thickness from 0.002 to 0.020 in. Coatings can be applied to any size or shape of article. Spraying can be used to salvage defective or damaged coat-

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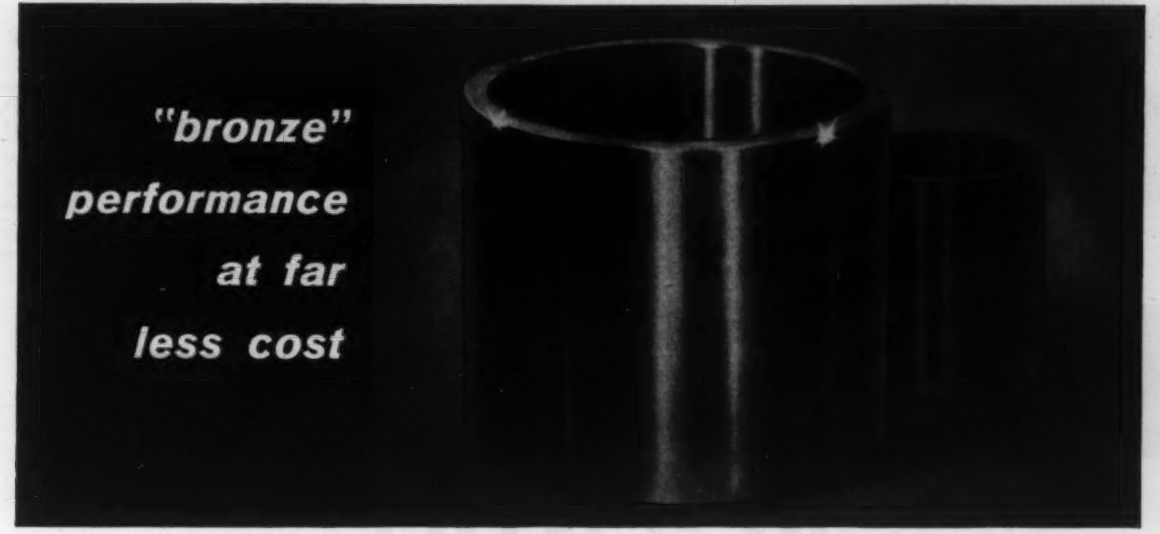

The important difference between the porous bronze bearing (right) and the all-new Iron OILITE* 212 Bearing (left) is cost. While both bearings give long, maintenance-free service, Iron Oilite 212 bearings now open the door to major savings for many equipment manufacturers.

Performance-proved in life tests and on actual products, Iron Oilite 212 bearings have a service life equal to porous bronze when used for products where corrosion is not a problem and mechanical strength requirements are within tolerable limits.

A high oil content — approximately 20% by volume — assures adequate lubrication for the lifetime of many end products. In addition, a unique built-in service factor gives Iron Oilite 212 bearings extraordinary protection against temporary overloads. They perform best when carrying medium to heavy loads at relatively low speeds and readily equal the performance of bronze at the high speeds required by home appliances, fractional horsepower motors, power tools, light machinery and other products.

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of IRON OILITE 212 Bearing 1" ID x 1¼" OD x 1" Length and full information on request. Consult the Oilite engineer in your area. Find him in the Yellow Pages under "bearings" or write direct to Amplex. Address Dept. S-2.

COMPARISON OF TYPICAL PHYSICAL PROPERTIES

	Iron Oilite 212	Oilite Bronze
Porosity, % oil by volume	18 - 23	18 - 23
Ultimate Tensile Strength, (psi)	10,000	18,000
Compressive Yield Point, (psi)	9,500	20,000
Rockwell Hardness	RH - 35	RE - 65
Specific Gravity	6.1 - 6.5	6.4 - 6.7

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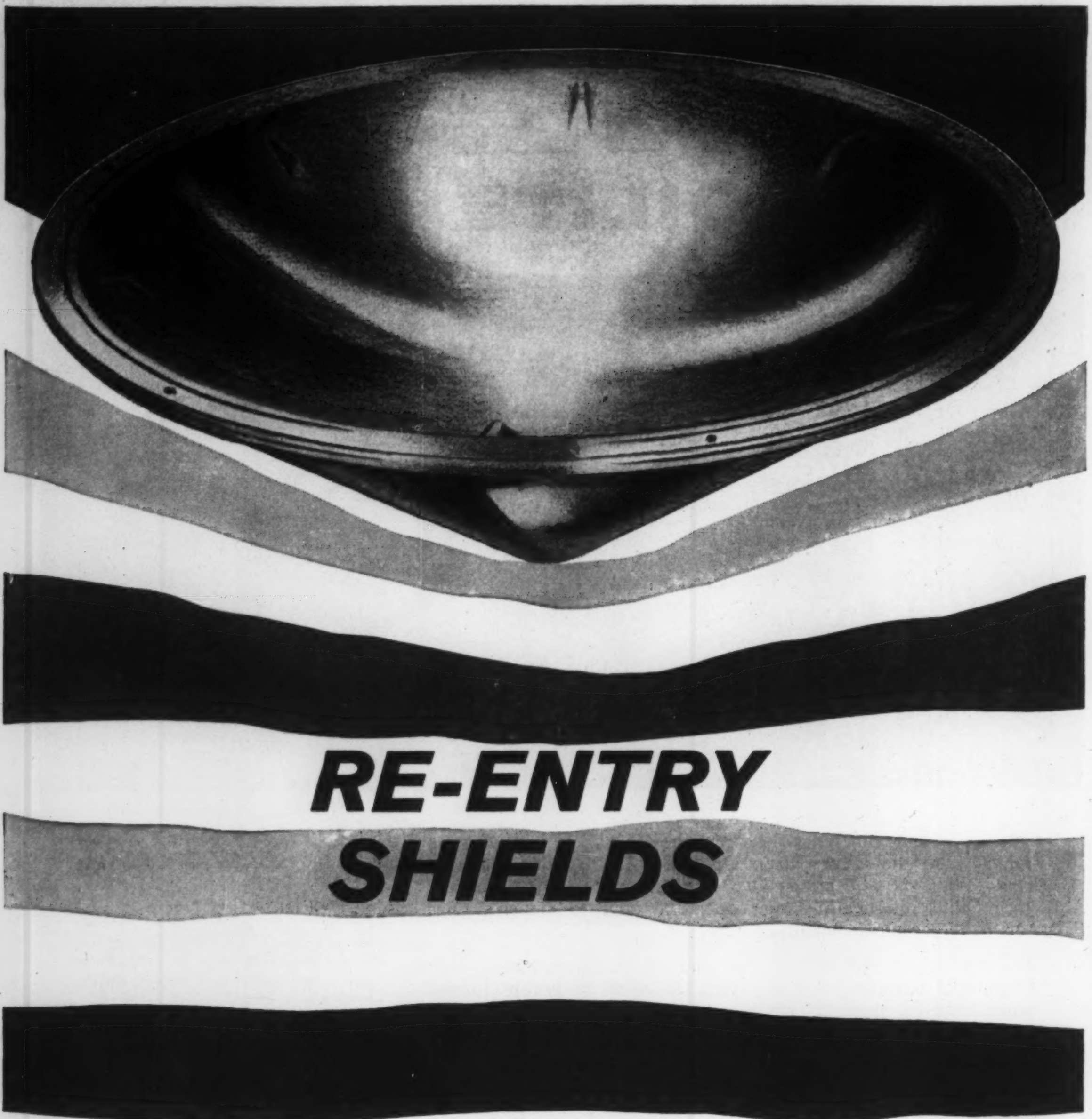

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ings made by other aluminum coating processes.

There are four systems or metallizing processes in use for protecting steel at elevated temperatures. They are patented by the Metallizing Engineering Co. of Westbury, L. I. Each may be used for a particular range of temperature and service conditions as outlined.

System 120: This system provides satisfactory protection for iron and steel from atmospheric corrosion at elevated temperatures to approximately 900 F. The surface to be protected is first grit blasted and then metallized with a coating of aluminum 0.006 in. thick. Two coats of a special sealer are then applied to the sprayed metal. The sealer is a silicone type and contains aluminum pigment. The sealer fills the pores of the sprayed metal with a moisture-repellent material. The resulting combination of coatings resist severe atmospheric corrosion and is suitable for exposed parts operating at temperatures to 900 F.

Process 11: This is an inexpensive yet satisfactory method for protecting iron or steel surfaces from corrosive action of hot gases at temperatures at 1600 F. The surface to be protected is first grit blasted and then metallized with a coating of aluminum. A special sealer is then applied to the sprayed metal coat. This sealer has a bitumastic base and contains aluminum pigment. The part is then heat treated to cause penetration of the aluminum into the iron or steel surface.

The sealing coat protects the aluminum from oxidizing and gives it time to be absorbed by the iron or steel. Eventually the sealer burns through, permitting the external surface of the aluminum to oxidize. The final coating, therefore, consists of an external surface of aluminum oxide and, under this, a coating of aluminum in solid solution in iron. Near the surface, concentration of aluminum is relatively high. After heat treating, the part is wire brushed.

Process 33: This process is used for protecting iron and steel against the action of corrosive gases where temperatures range from 1600 to 1800 F and where the gases do not

Onan NEWS REPORT

Onan 13 H.P. engine powers 100-mile-an-hour air blast!

This Model 50 Rotomist, manufactured by the John Bean Division of Food Machinery and Chemical Corporation, is a highly mobile mist sprayer used for pest control, sanitation, and treatment of tree diseases. Powered by a 13 horsepower Onan CCK engine, the Rotomist delivers 12,000 cubic feet of air per minute at a velocity of 100 miles per hour.

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Onan PRODUCTOS

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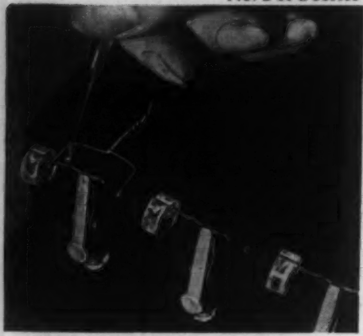
No. 2 of a series



Eastman 910 Adhesive solves another production bottleneck

Universal Transistor Products Corp., Westbury, New York, makes a direct-reading precision radiation monitoring instrument, called a dosimeter.

Assembly of the pocket instrument requires careful attachment of the sensing element, an extremely delicate quartz fiber, to two pips on a fine aluminum wire.

This seemingly difficult operation is handled on a production-line basis with speed and simplicity by properly positioning the fiber, which is temporarily held in a Y-shaped support, and then cementing it to each pip with a drop of Eastman 910 Adhesive.

In less than one minute, the bond is formed.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

Eastman 910 Adhesive

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For a trial quantity (⅓-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9106 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. M-6, Kingsport, Tenn.

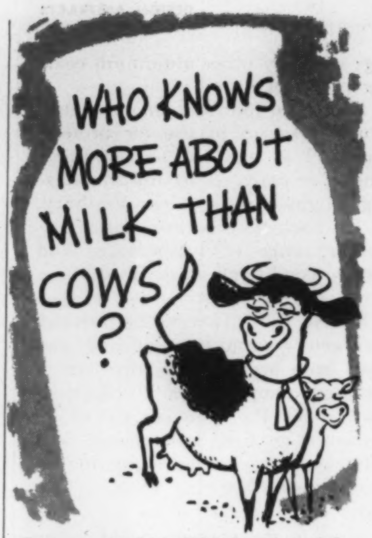
Circle 513 on Page 19

contain large amounts of sulfur. It is applied by first grit blasting the surface and then spraying on a thickness of approximately 0.010 in. of a special chromium-nickel alloy. The sprayed surface is then painted with a special bitumastic sealer containing metallic aluminum. No heat treatment is required. Any alloying of the metals takes place in the first heat when the part is put in use.

Separate heat treatment is avoided with this process because the porous, sponge-like structure of the sprayed chromium-nickel layer presents an absorbent base into which the aluminum paint penetrates. Although very little aluminum is present, it is thought that it alloys with chromium, nickel, and iron and may penetrate through the sprayed coating and alloy to the base metal. In this manner it forms an actual alloy bond consisting of chromium, nickel, aluminum, and iron. This helps seal the pores against the penetration of gases. However, as no appreciable amount of aluminum remains on the outside, the chromium-nickel alloy is exposed to hot gases. Therefore, the coating will not withstand the corrosive action of strong sulfur gases.

Process 45: This process provides maximum protection against heat oxidation, withstanding even strong sulfur gases. It is applied on iron or steel by first grit blasting the surface and then spraying on a coating of a special chromium-nickel alloy to a thickness of approximately 0.015 in. This is 50 per cent thicker than the coating used in Process 33. Pure aluminum is then applied by metallizing on top of the chromium-nickel coating. Next, a bitumastic sealer containing aluminum pigment is applied on the outside of the aluminum. No heat treatment is required since the first heat of the part will cause alloying.

As in the case of Process 33, the aluminum rapidly penetrates into the porous structure of the chromium nickeled coating forming an alloy bond with the base metal. The larger amount of aluminum used in this process also causes a more complete alloying throughout the mass of the coat. As this alloying takes place, the coating, while still somewhat porous, becomes impervious to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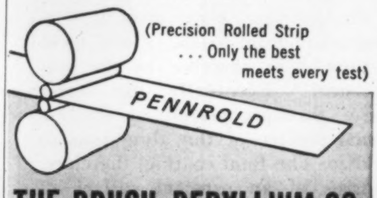

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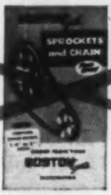
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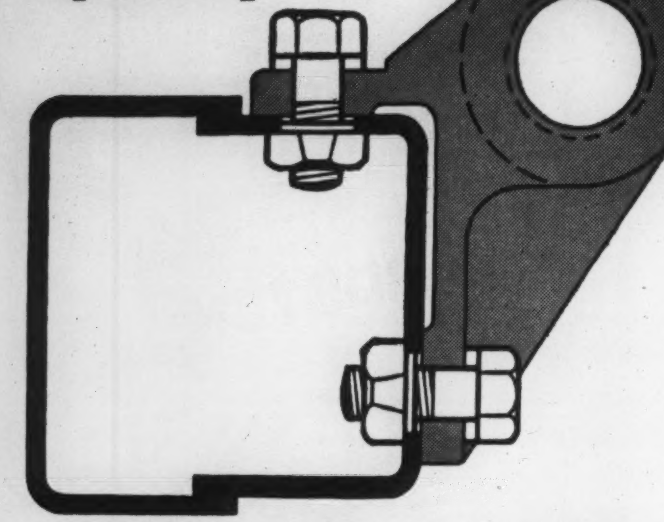

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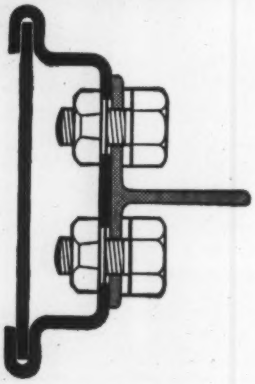

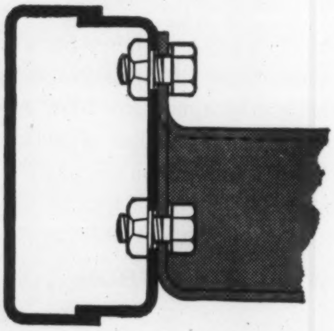

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MIDLAND WELD NUT

Circle 516 on Page 19

the penetration of gases.

SAE paper 40-T, *SAE National Production Meeting, Detroit, Mich., March,* 1959; 11 *pp.*

lubrication

High-Torque Performance of Extreme-Pressure Lubricants

R. K. Nelson and L. J. Valentine, Eaton Manufacturing Co.

Results of a dynamometer test of horsepower and high-torque absorption of EP lubricants of the GL-4 specification. These lubricants, conforming to the new Military L-2105A, were compared with those conforming to Military L-2105 specification. Results show that lubricants conforming to the new specification are capable of withstanding continuous high-horsepower applications where relatively low torque is required. However, they do not compare favorably with extreme-pressure lubricants of the older specification in regard to continuous high-torque applications.

ASLE paper 59GS-13, *ASLE First Gear Symposium, Chicago, January,* 1959; 10 *pp.*

An Over-All Look at Gear Lubrication

A. Hundere, Alcor Inc.

Comments on the present state of the art of gear lubrication. Discussion includes fundamentals of gear lubrications, scoring or scuffing, tooth-surface temperatures, effect of operating variables on scuffing, gear-tooth pitting, gear-lubricant testing, and simplified tests for determining load-carrying ability of gear lubricants. Suggestions for further research are included.

ASLE paper 59GS-1, *ASLE First Gear Symposium, Chicago, January,* 1959; 18 *pp.*

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SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

ASLE—American Society of Lubrication Engineers, 84 East Randolph St., Chicago 1, Ill.; papers 35 cents to members, 50 cents to nonmembers.

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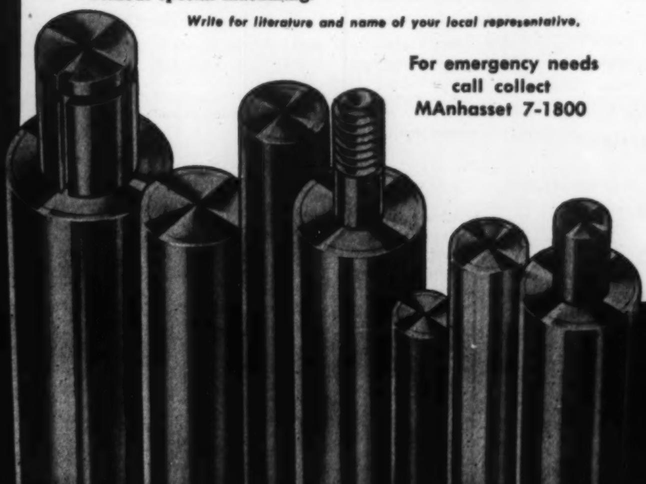

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photo . . . courtesy J. I. Case Company, Racine, Wis.

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Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—Page 19

Aviation Accessories

Concise descriptions and illustrations of an extensive line of accessories for aviation, missile, and space craft industries are found in illustrated catalog. Covered are eddy current dampers, magnetic brake, rotary actuator, linear actuator, hydraulic control valve, and bevel gear differential. 26 pages. Lyndon Aircraft, Inc., 140 Clifford St., Newark 5, N. J. D

Circle 651 on Page 19

Phototubes

"Phototubes and How to Use Them" is title of guide to these photoelectric devices. Typical circuits demonstrate the use of high-vacuum and gas-filled phototubes. Also included in Bulletin PA-227 are details of a miniaturized circuit using transistors and a photocell. 6 pages. Columbia Broadcasting System, Inc., CBS-Hytron Div., Parker Street, Newburyport, Mass. B

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Vinyl-Metal Laminate

Lasting surface textures, abrasion resistance, acid and alkali resistance, protection against corrosion are features of Clad-Rex vinyl-metal laminate. Detailed in illustrated bulletin, it requires no special tooling for fabrication. Properties, applications, and methods of fastening are shown. 8 pages. Clad-Rex Corp., 2101 Indiana Ave., Chicago 16, Ill. J

Circle 653 on Page 19

Rotary Torque Actuator

Design, performance, and application characteristics of the Carter pneumatic or hydraulic rotary torque actuator are cited in Bulletin RA-500. This compact device is offered in 4 to 12-in. bore sizes with outputs to 13,700 lb-in. and in standard rotation ranges of 0 to 100 to 0 to 370 degrees. 12 pages. Carter Controls, Inc., 2800 Bernice Rd., Lansing, Ill. J

Circle 654 on Page 19

Subminiature Switches

Subminiature toggle, pushbutton, and high amperage snap-action switches are described and illustrated in Bulletin 98-33. General and specific characteristics of each are covered. A section is devoted to actuator brackets for slide or cam action. 4 pages. Milli-Switch Corp., 555 Hoke Ave., Frankfort, Ind. J

Circle 655 on Page 19

Printed Circuit Connectors

A wide variety of printed circuit connectors which accommodate 1/16, 3/32, and ⅛-in. printed circuit cards are described in Bulletin PC600. Various wiring styles and molding compounds can be specified. Dimensions and application information are included. 24 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 656 on Page 19

Miniature Speed Reducers

Over 400 fixed ratios are available in Series 8 and 9 miniature speed reducers described in Bulletin 97. Speeds up to 10,000 rpm and torques up to 24 oz-in. are available. 4 pages. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo. K

Circle 657 on Page 19

Brass Hose Fittings

Brass hose fittings for air, spraying, and welding services are described in Bulletin 198. Dimensions and application data are given on Le-Hi nipples, couplings, menders, ferrules, and adapters. 4 pages. Hose Accessories Co., 2704 N. 17th St., Philadelphia 32, Pa. E

Circle 658 on Page 19

Aircraft Tubing

Revised and up-dated Technical Handbook A-2 presents complete data on seamless aircraft tubing in carbon and alloy steels. Covered are definitions, military and AMS specs, sizes, tolerances, machining, heat treating, properties, and many other pertinent facts. Charts, drawings, and tables amplify the text. 70 pages. Copperweld Steel Co., Ohio Seamless Tube Div., Shelby, Ohio. G

Circle 659 on Page 19

Thin Electric Motors

Offered in 1 to 5-hp ratings in dripproof and enclosed designs, Thinline electric motors are up to 8 in. shorter and 26 lb lighter than standard flange-mounted motors. Matching standard NEMA frame diameters, motors are especially suited for limited space mounting. Design and application information are given in Bulletin GEA-6927. 8 pages. General Electric Co., Small Integral Motor Dept., Fort Wayne, Ind. J

Circle 660 on Page 19

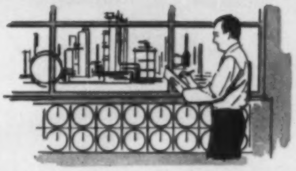
Electrical Connectors

Information to aid in selection and application of electrical connectors for industry is given in Catalog B 73. Design and performance features of oval and round push-pull, push-latch, Quik-Loc, straight pin Bigun, push-lock, and change-out styles are presented. Contact arrangements are shown. 12 pages. Joy Mfg. Co., Electrical Products Div., 1241 Macklind Ave., St. Louis 10, Mo. I

Circle 661 on Page 19

SPECTROL PRECISION MECHANISMS

One Man, Black Boxes, and Process Control



Speeding up instream process control frequently requires more ingenuity than cash.

Bearing on this point, Spectrol recently made a number of cleverly engineered black boxes for one of the country's leading refineries. This device, known as an Indicating Process Monitor, takes inputs from flow, temperature, and pressure transducers, measures them and delivers any necessary corrective action through a servo loop. The information is visually presented on dials incorporating adjustable set points. Output from this Spectrol black box also drives a variety of data handling, display, and recording equipment.

Here's how it works. After a given physical quantity is transduced to a voltage, it passes through a difference sensing network to a servo-amplifier. The amplifier output voltage operates a motor and speed reducer which drives several Spectrol precision potentiometers ganged on a common shaft. The output voltage of one of these potentiometers has a linear relationship to the indicator setting and is used for negative feedback. The difference between this voltage and the transducer input voltage becomes the servo error signal. Rotation of the system continues until the error signal becomes zero and the indicator reads the new value of the physical quantity under consideration. Meanwhile, other potentiometers on the shaft send voltages to various instream control devices which raise and lower pressures, temperatures, and so forth until the process takes place at the desired rate. Static accuracy is 0.2%.

The visual monitoring task of the observer is simplified by mounting the meter on an easily rotated chassis so that anticipated output in terms of arbitrary units from 1 to 100 can always be read with the needle in an upright position. This feature minimizes observer error where several predetermined outputs are viewed continuously. If black box A is set at 85, B at 40, and C at 100, the operator merely rotates each Spectrol precision mechanism until the respective needle reads the value in an upright position. He can quickly note and correct any processing circuit that leaves boundary conditions.

Of course, these devices are readily adaptable to the more esoteric tasks of reading fuel flow, pressure and temperature in a missile launch blockhouse. Here, human engineering of visual displays is of vital concern.

In a nutshell, advantage of this instance of Spectrol's unique approach to automation is a package one-fifth the size for 40% less than the way the refinery used to do the same job.

More information, including a helpful 8 page booklet, on this and other Spectrol precision mechanisms designed for use as functional sub-systems is yours for the asking. Simply call your nearest Spectrol sales engineering representative or address Department. 576.

8

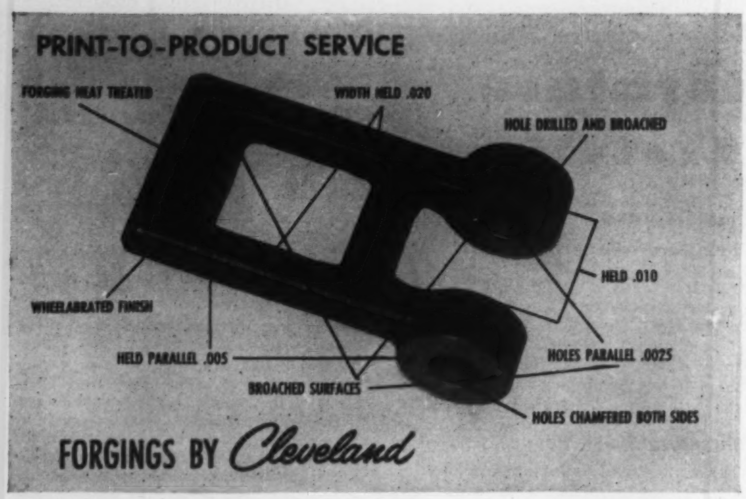
SPECTROL

ELECTRONICS CORPORATION

Sales engineering representatives in principal cities.

1704 S. DEL MAR AVE., SAN GABRIEL, CALIFORNIA

Circle 519 on Page 19



How many of these steps does your product need?

If you can use skills and close tolerances like these, write for information to *Forge & Fittings Division, H. K. Porter Company, Inc., Cleveland 4, Ohio.*

FROM A SINGLE SOURCE:

FORGINGS . . . Hammer, Press, Upset
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Circle 520 on Page 19

RMB FILMOSEAL BEARINGS

"Big Bearing" Construction in High Precision Miniature Sizes

Sizes from .1875" OD—0.0550" Bore

RMB Filmoseal Miniature Ball Bearings have all the features of a big bearing including:

- Deep groove races
- Balanced two-piece or snap-type ball retainer
- Non-rubbing capillary oil seal
- Precision tolerances

Available in ABEC-5 and ABEC-1 tolerances, Filmoseal Bearings combine all the advantages of sealed bearings with the rotational freedom of open bearings. There is no mechanical contact between rotating and stationary parts—lubrication is retained and foreign matter is excluded by an oil encased, non-rubbing capillary seal.

Fifteen different sizes are available for prompt delivery with experimental quantities ready for immediate shipment from stock. Filmoseal bearings are just a few of the complete RMB line of miniature ball and roller bearings. They're described in the RMB catalog which we'll be glad to send to you on request. Write for your copy today.

LANDIS & GYR, INC.

45 West 45th Street New York 36, N. Y.

Circle 521 on Page 19

Dial Pressure Gages

Design features and application data on the RMC line of dial type high pressure gages which withstand cycling, vibration, overload, and other extreme service conditions are pointed out in Bulletin CL1-59. Ranges extend up to 10,000 psi. 6 pages. Rochester Mfg. Co., 100 Rockwood St., Rochester 10, N. Y. N

Circle 662 on Page 19

Castings

"The HTM Story" explains how this company casts HTM using green sand, CO_2, or the shell molding process. Photomicrographs show grain structure. Properties of metals are charted, and physical properties and machinability ratings are tabulated. 8 pages. National Malleable & Steel Castings Co., 10600 Quincy Ave., Cleveland 6, Ohio. G

Circle 663 on Page 19

Swivel Casters

Having load capacities of 175 to 700 lb, 900 Series swivel casters are designed for medium to heavy duty applications. These ball bearing casters are available with 3 to 8-in. diameter wheels. Full information is given in Bulletin 1759. 4 pages. Faultless Caster Co., Evansville 7, Ind. J

Circle 664 on Page 19

Chain Lubrication

How to best lubricate chain drives is explained in bulletin entitled "Lubrication of Roller and Silent Chain Drives." Oil selection charts are presented in addition to principles of lubrication and maintenance suggestions. 4 pages. Sun Oil Co., Industrial Products Dept., 1608 Walnut St., Philadelphia 3, Pa. E

Circle 665 on Page 19

Precision Limit Switch

According to Bulletin M-1, the new Loxswitch precision limit switch has a life in excess of 55 million cycles. It is suited for up to 600-v ac or dc service and is rated 20 amps on 125-v ac. Range of operating levers is described. 4 pages. R. B. Denison Mfg. Co., 102 St. Clair Ave. N.W., Cleveland 13, Ohio. F

Circle 666 on Page 19

Metal Shapes

Illustrated handbook entitled "Roller Die Cold Formed Metal Shapes" is guide to how, where, and when to use these products. Useful engineering and fabricating data are presented. 48 pages. Van Huffel Tube Corp., Warren, Ohio. G

Circle 667 on Page 19

Tubular Product Stock

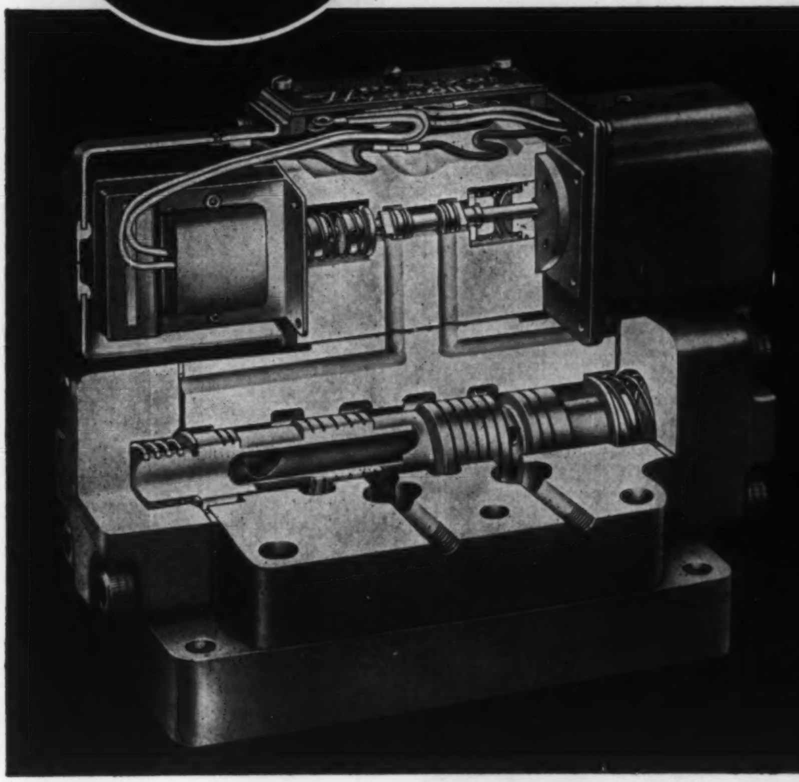
Typical applications of Rockrite tubing in straight, taper, or special configurations are given in Bulletin SP-1. Performance data are tabulated for K-Monel, zirconium, columbium, stainless, and other special metal and alloy tubings. Design and fabrication advantages are disclosed. 4 pages. Tube Reducing Corp., Box 959, Passaic, N. J. D

Circle 668 on Page 19

NEW
from
DENISON

4-WAY VALVES

Pilot-operated, solenoid-controlled for hydraulic systems up to 5000 psi



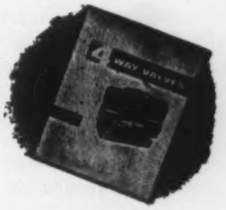
- SHORTER OVER-ALL LENGTH than any comparable valve
- SHORTEST SOLENOID POWER STROKE increases operating force
- DRAWN STEEL SOLENOID COVERS secured to body with *internal retaining cords.* No bulky, dirt-collecting chains
- BUILT-IN CHECK VALVE provides pilot pressure without adding another valve to the system
- LARGE CAPACITY PORTING for low pressure drop
- GENEROUS WIRING SPACE with ½" conduit connections on each side
- TEST CONNECTIONS for checking valve operation
- HEAVY DUTY SOLENOIDS optional D.C. operation oil-immersed solenoids available
- BUILT TO JIC STANDARDS

SHOCKLESS HYDRAULIC CONTROL for any directional control requirement is assured with Denison's new line of 4-Way Valves.

Here are *more reasons why* the exceptional design versatility of these new 4-Way Valves is important to Hydraulic Engineers—

1. Provide fast, rapid-cycle directional control of hydraulic flows up to 30 gpm.
2. Operating pressures range up to 5000 psi for both ¼" and ¾" valve sizes.
3. Operate in any porting and positioning combination.
4. Solenoid-operated ¼" valve capacity—5 gpm.
5. Pilot-operated, solenoid-controlled ¾" valve capacity—30 gpm.
6. Choice of spool types and spool positioning provides unlimited combinations for a wide range of applications.
7. Adjustable pilot chokes available for smooth spool reversal.
8. Interchangeable parts simplify service and model changes in the field.
9. Easily modified for operation on internal or external pilot pressure by rotating solenoid valve 180°.

DESIGNERS
ENGINEERS!
Send for Bulletins VD-7, VD-8 and 240-B



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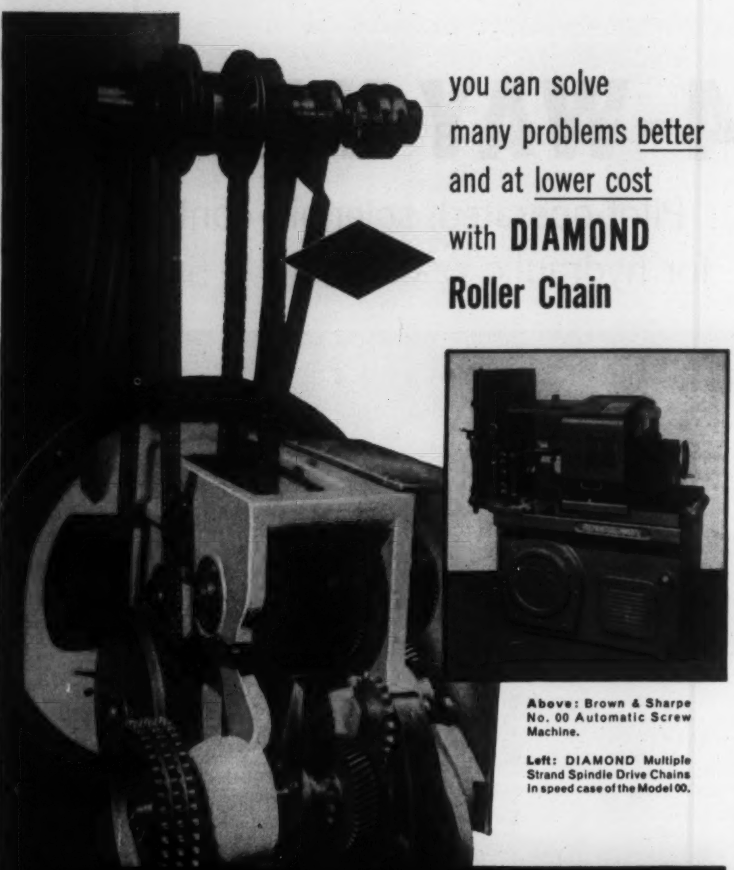

you can solve many problems better and at lower cost with **DIAMOND** Roller Chain

Above: Brown & Sharpe No. 00 Automatic Screw Machine.

Left: DIAMOND Multiple Strand Spindle Drive Chains in speed case of the Model 00.

DIAMOND
ROLLER CHAIN

proven for trouble-free, precision performance

DIAMOND Roller Chain is used throughout the entire Brown & Sharpe screw machine line. On motor, spindle and auxiliary drives—for flexible shaft couplings—DIAMOND Chain dependability was first proved by exhaustive tests on the new Model OO . . . subsequently confirmed on hundreds of machines now in the field.

When you specify DIAMOND you get traditional high quality that assures long operating life. Write for catalog . . . engineering service is available.

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Offices and Distributors in all Principal Cities

DIAMOND ROLLER CHAINS

Circle 523 on Page 19

Socket Cap Screws

The Series 60 Allen socket head cap screw line is reported to give up to 2 1/3 times more load carrying capacity than previous screws because of larger head. Bulletin G-25 gives complete design data on No. 0 to 10 and ¼ to 1-in. sizes. 4 pages. Allen Mfg. Co., Hartford 1, Conn. B

Circle 669 on Page 19

Fire-Safe Lubricants

"Explosion-Safe, Fire-Resistant Lubrication for Air Compressors" presents comparative auto-ignition temperatures of petroleum compressor oils and Houghto-Safe 1120 fire resistant lubricant. Advantages of this fluid are outlined. 6 pages. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 670 on Page 19

Vinyl Clad Metal

Questions and answers are used in "Memo to Appliance Manufacturers" to explain the advantages of Colovin nonstaining white vinyl metal laminate. Vinyl sheeting can be laminated to steel, aluminum, and other metals. 4 pages. Columbus Coated Fabrics Corp., Columbus 16, Ohio. G

Circle 671 on Page 19

Industrial Products

Anchors, screws, toggles, and masonry drills; wire connectors; plastic straps and clamps; wiring tools; snap-straps; drive-straps; fuse specialties; and testers are among electrical and mechanical products described in Catalog 100. 32 pages. Holub Industries, Inc., Sycamore, Ill. I

Circle 672 on Page 19

Switches

Condensed Catalog and Price List 608 describes basic snap action, enclosed snap action, foot, mercury, and actuating control switches. Basic Klikswitch is a precision snap-action unit built into a molded plastic case. 4 pages. General Controls Co., Automation Controls Div., 8062F McCormick Blvd., Skokie, Ill. J

Circle 673 on Page 19

Fluid Control Valves

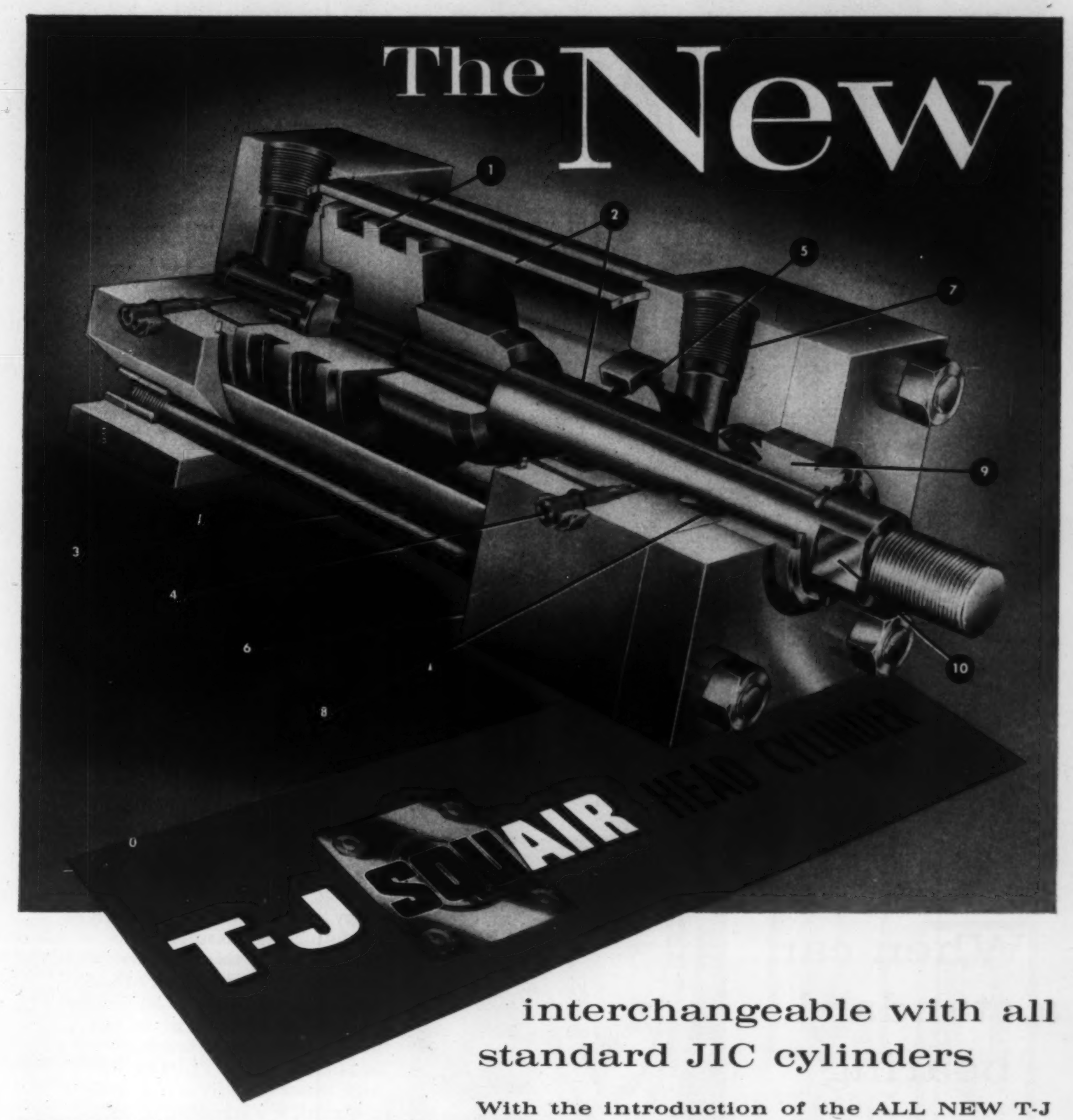
Color coded valve simplifies adjusting, reading, and recording of Colorflow control valves described in Catalog M-101. They are used to control flow of air, oil, water, gas, and other fluids at working pressures to 5000 psi. 2 pages. Manatrol Corp., 2108 Payne Ave., Cleveland 14, Ohio. G

Circle 674 on Page 19

Drafting Room Equipment

Equipment for the drafting room, artist, and school is reviewed in Catalog GC-59. Newest member of this Stacor line is the Staktube roll file for large rolled blueprints, charts, and tracings. Flat drawer files and drawing and drafting tables are included. 24 pages. Stacor Equipment Co., 295 Emmet St., Newark, N. J. D

Circle 675 on Page 19



interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

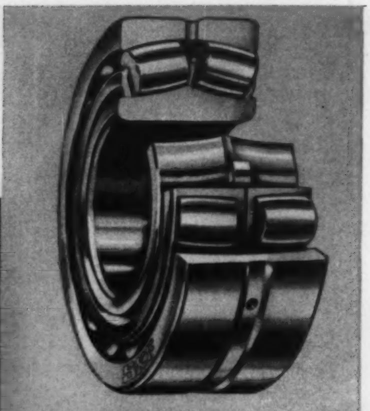
8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

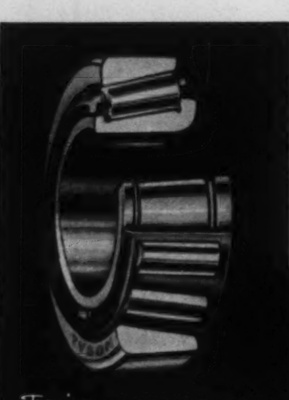
10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J
TOMKINS-JOHNSON

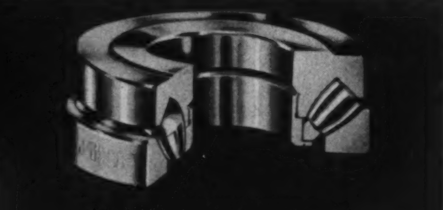
Circle 524 on Page 19



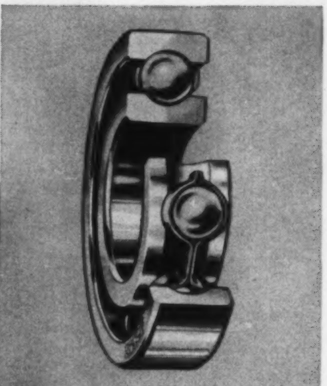
Spherical Roller Bearing



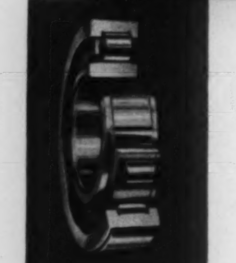
Tyson Tapered Roller Bearing



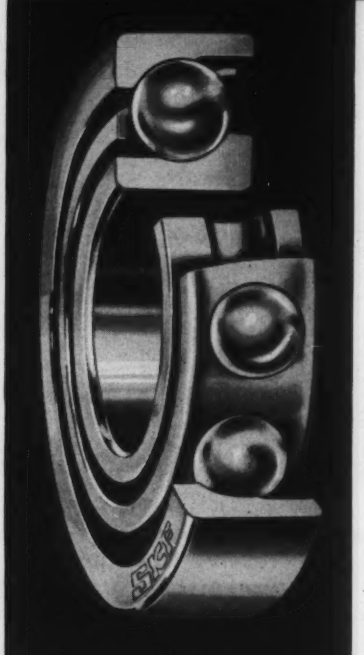
Spherical Roller Thrust Bearing



Single Row
Deep Groove Bearing



Cylindrical
Roller Bearing



Angular
Contact Bearing

When can a standard bearing do a "special" job?

Suppose you need a high speed bearing to support either heavy thrust load or thrust load combined with radial load. It is almost a certainty that SKF angular contact ball bearings will do the job.

SKF bearings of this type are produced in bore sizes ranging from ¾" to just over 7". They lend themselves to all sorts of mountings. For example, you can mount them in pairs either face-to-face or back-to-back where axial rigidity and high radial capacity are needed. Or you can mount two or more bearings in tandem, where a particularly high thrust capacity is required.

Yet this is a standard SKF bearing, promptly available in over 80 sizes of single- and double-row types.

Almost every SKF bearing can do "special" jobs for you. Why not find out how they'd be more efficient and economical? Call any one of the twenty-five sales offices.

5924

Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

Circle 525 on Page 19

Industrial Pumps

Both centrifugal and rotary pumps for use in a wide range of equipment and applications in industry are described in illustrated catalog. Pumps have ratings from 1/20 to 5 hp, deliver from 1 pt to 148 gal per min, and operate at pressures to 54 psi. Details are given on pump parts and accessories, as well as on several models of coolant systems. Complete engineering data are included. 72 pages. Detroit Harvester Co., Pioneer Pumps Div., 21800 Greenfield Rd., Oak Park 37, Mich. H

Circle 676 on Page 19

Electrical Connectors

Details of the complete new line of ARK-trol electrical connectors are given in Bulletin 2711. The plugs and receptacles are of environment-resistant construction and operate at temperatures from −80 to 225° F. They withstand pressures to 300 psi external and 200 psi internal. Types and sizes are available for every need. 48 pages. Crouse-Hinds Co., Syracuse 1, N. Y. N

Circle 677 on Page 19

Metal Spinning

Facilities for extensive metal spinning and hydroforming are shown in illustrated brochure along with typical parts formed by these methods. Parts up to 85 in. in diameter by 1/8 in. thick are spun in steel, stainless, aluminum, brass, copper, and Monel. 12 pages. J. Schrader Co., 4603 Fenwick Ave., Cleveland, Ohio. G

Circle 678 on Page 19

Timing Belt Drives

Time-Tex timing belt drives combine the advantages of ordinary Texrope drives with those of chain and gear drives. Described in Bulletin 20B8760, drives are suitable for loads from subfractional to 600 hp and speeds from 0 to 16,000 fpm. 4 pages. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. K

Circle 679 on Page 19

Aluminum Magnet Wire

Illustrated Brochure W-154 discusses economic and functional advantages of aluminum magnet wire and gives information on properties, insulating characteristics, and winding and connecting techniques. Conductivity is a minimum 62.7 per cent IACS. 6 pages. Kaiser Aluminum & Chemical Sales, Inc., Dept. NR-34, 919 N. Michigan Ave., Chicago 11, Ill. M

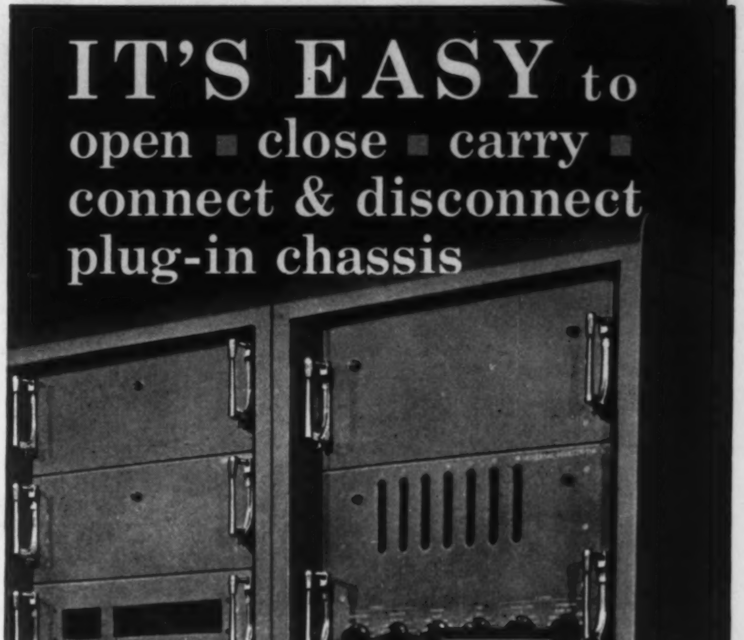
Circle 680 on Page 19

Rubber Coated Fabrics

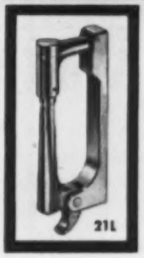
Specifications and characteristics are given for many Reevecote natural and synthetic rubber-coated fabrics in Catalog SF-9. Line offers some 96 items with Buna-N, neoprene, natural rubber, and special elastomer coatings. 8 pages. Reeves Brothers, Inc., Vulcan Rubber Products Div., 1071 Avenue of the Americas, New York 18, N. Y. D

Circle 681 on Page 19

DATICO "digital automatic tape intelligence check out" is made by the Nortronics Div. of Northrop Corporation for the U. S. Air Force and U. S. Army Rocket & Guided Missile Agency. This money and man saving tool provides rapid weapon system evaluation. Note Camloc Chassis Latches.



IT'S EASY to open ■ close ■ carry ■ connect & disconnect plug-in chassis



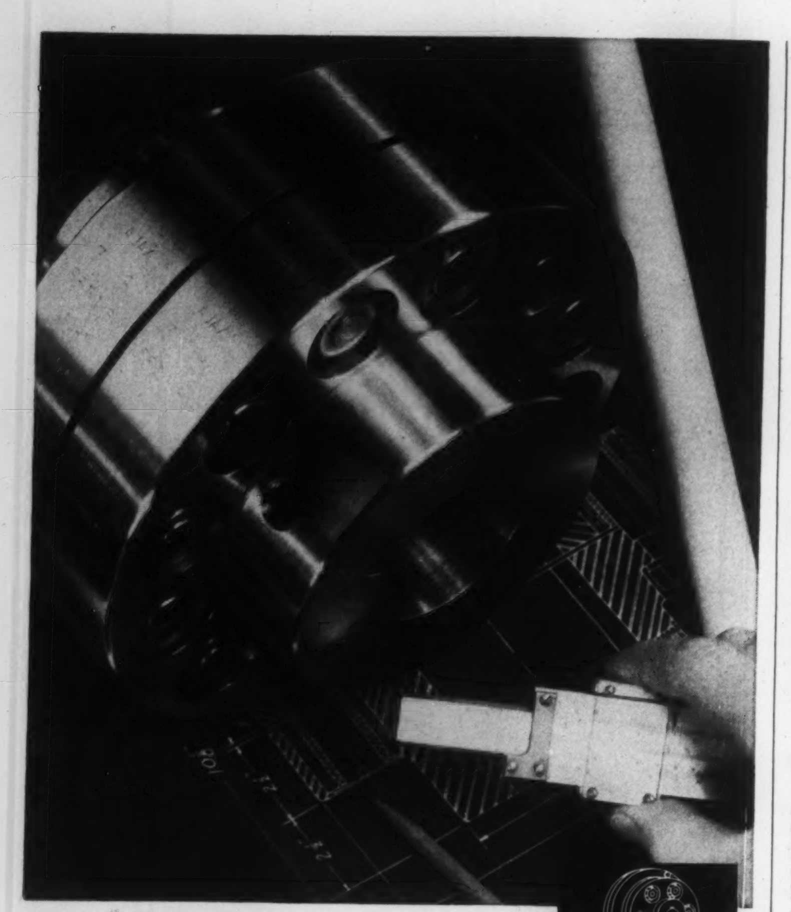
with CAMLOC® multi-function CHASSIS LATCHES

Thirty-eight strong, simple, attractive Camloc multi-function Chassis Latches are used on the 24 equipment filled plug-in chassis that make up DATICO, the military's new universal automatic field service checkout system. Here is a perfect example of designed-in fastener serviceability, flexibility, ease of handling and economy in interconnected "black-box" systems. When the Camloc push-button handles are released and pulled down, the chassis is automatically disconnected and ejected. Then the latch becomes a carrying handle. When replacing the equipment the latch firmly pulls the chassis back in place, making perfect, automatic reconnection of multiple-pin units. It is quick, safe, reliable, vibration-proof. Camloc Chassis Latches consist of only two parts—a handle and a fork—mounted with standard screws. Several handle and fork designs are currently available, all interchangeable. *Write for Camloc's new Bulletin 35L today.*

"Specialists in Fasteners for Industry"

CAMLOC FASTENER CORP. • 37 SPRING VALLEY RD., PARAMUS, N. J.
WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CALIF. • SOUTH WEST OFFICE: 2509 W. BERRY ST., FORT WORTH, TEXAS

Circle 526 on Page 19

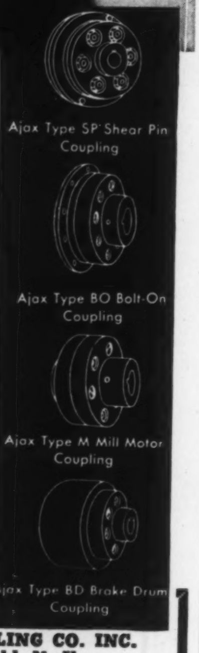


Never Underestimate the Economies of AJAX Flexible Couplings

The fact that *All the Horsepower goes through the coupling* is proof of its importance. In safeguarding performance . . . in reduced maintenance . . . in freedom from breakdowns and costly repairs, Ajax Flexible Couplings add to the reliability, reputation, and economy of the machines you build.

Ajax offers America's most complete line of bronze bushed, rubber cushioned and Dihedral gear type couplings available from stock for heavy machine and light duty service.

Write for complete engineering and selection data.


Ajax Type SP Shear Pin Coupling
Ajax Type BO Bolt-On Coupling
Ajax Type M Mill Motor Coupling
Ajax Type BD Brake Drum Coupling

AJAX

AJAX FLEXIBLE COUPLING CO. INC.
102 Portage Road, Westfield, N. Y.

Send catalog covering Flexible Couplings.

Name ____________________
Concern ____________________
Address ____________________

Circle 527 on Page 19

Stampings & Wire Forms

Lugs, clips, terminals, and hundreds of other stampings, as well as special wire forms are illustrated in sketches and plan drawings in Catalog 22. Small metal parts are hot tinned for easy soldering. 58 pages. Zierick Mfg. Corp., 110 Beechwood Ave., New Rochelle, N. Y. D

Circle 682 on Page 19

Tables & Formulas

Convenient tables, formulas, and graphical symbols provided in Booklet B-3677D summarize electrical data, properties of materials, heat transfer and steam information, and measurements. 120 pages. Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa. F

Circle 683 on Page 19

Screw Conveyor Drives

Compact screw conveyor drive featured in Bulletin A667C is available in four sizes with ratios of 3:1 with single reduction gearing and up to 18:1 with double reduction gearing. Tables facilitate selection of units and V-belt drives for various loads and speeds. 16 pages. Dodge Mfg. Corp., Mishawaka, Ind. J

Circle 684 on Page 19

Heavy Duty Compressors

Pertinent data on 14 sizes of heavy-duty industrial compressors ranging from 95.6 to 939 cfm are given in Bulletin A-44. Section drawings and installation photos are presented for the WGO-9 Oil-Free compressors, along with a section on the T-block design compression ring. 12 pages. Joy Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa. F

Circle 685 on Page 19

Small Monel Tubing

"The Monel Family of Small Tubing" is described in Technical Bulletin CM-159 which lists chemical composition, physical constants, and mechanical properties of Monel, R Monel, 403 Monel, and K Monel tube forms. Typical uses of the four analyses are pointed up. 4 pages. Superior Tube Co., Norristown, Pa. E

Circle 686 on Page 19

Drive-Pin Blind Rivets

Designed for low driving load, P and F series of blind rivets are usable where other types could cause structural damage, such as in honeycomb structures, module units, plastics, and glass fiber. They are described in illustrated Bulletin DF-75. 6 pages. Deutsch Fastener Corp., Box 61072, Los Angeles 61, Calif. L

Circle 687 on Page 19

Quick Coupling Assemblies

OPW Kamlok quick coupling assemblies couple and uncouple instantly and withstand operating pressures up to 200 psi. Catalog F-10-R points up features, provides a chemical service chart, and gives general dimensions. 8 pages. OPW Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 688 on Page 19

Continental has the cure for vibration "headaches"

the one-piece locking screw that

won't work loose

IN MARKET CARTS — STAY TIGHT, RESIST SHOCKS OF SEVERE SERVICE

HOLTITE NYLOK hex head cap machine screw fastens chrome-plated steel tubing at right angles. Driven through holes in one section into tapped steel plug in end of adjoining part. Hold securely despite punishment of customer use.

IN CARBURETORS — HOLD ADJUSTMENT OF ANTI-STALL CONTROL

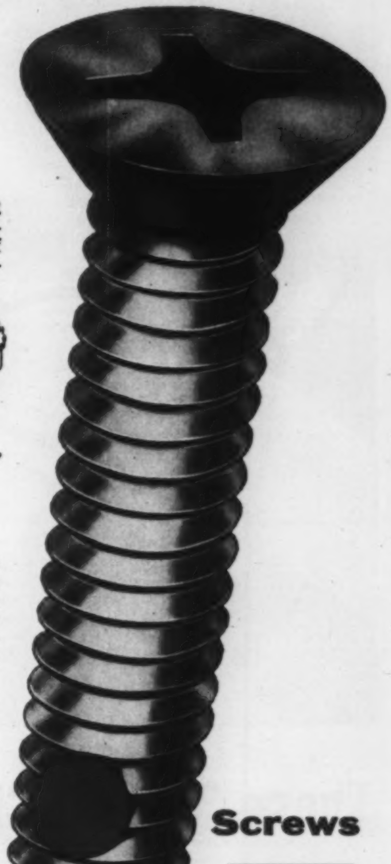
Hex head steel HOLTITE NYLOK machine screw maintains constant adjustment of anti-stall device attached to carburetors. Holds spring at required tension without variation through wide range of temperature changes.

IN EXHAUST FANS — HOLD MOTOR SECURELY DESPITE VIBRATION

Phillips truss head steel HOLTITE NYLOK machine screws are driven through rubber insulation mount into flange of vertical mounted motor. Screws do not loosen, resist constant vibration.

IN SHEARS AND SCISSORS — HOLD BLADES IN PROPER ADJUSTMENT

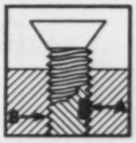
Binding head steel HOLTITE NYLOK machine screws are driven through drilled hole in one blade into tapped hole in mate. Hold proper blade contact, — permit easy disassembly for sharpening.



HOLTITE® NYLOK® Self-locking Screws

HOLTITE® NYLOK machine screws are the simplified self-locking fasteners with the Nylon insert that eliminates the need for lock washers, jam nuts, wiring and similar devices. If you have assemblies where screws *must stay* where they are set, NYLOK is your practical choice. The applications above show how you can save trouble and complaints, — give your product a sales advantage.

CHECK YOUR ASSEMBLIES — find out where Continental engineered fasteners, like HOLTITE NYLOK, can cut your assembly costs. Plan now to consult the Continental Assembly Specialists. They will analyze your operations and tell you which fasteners — *standard or special* — can save you most. For prompt service, write or phone: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Massachusetts.



Resilient nylon plug (A) sets up a lateral thrust, smoothly wedges mating threads together (B). All locking action is on threads: head is not stressed. Locking is positive . . . seated or unseated.

One piece — no separate parts
Can be removed and replaced
Interchangeable — reusable
Locks seated or unseated
Acts as seal for gases, liquids

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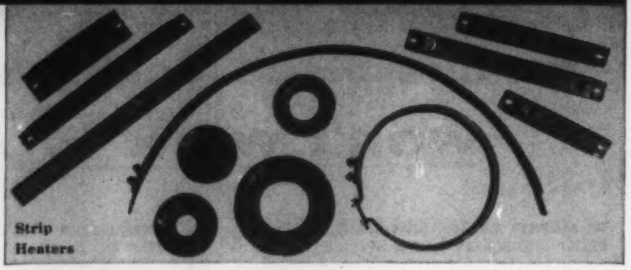
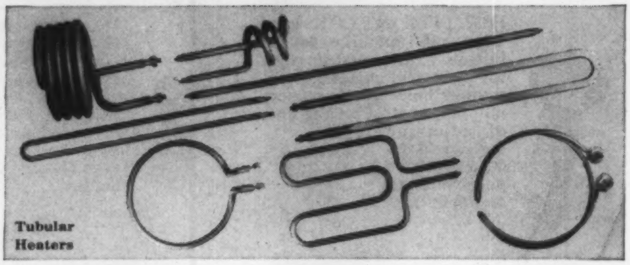
Circle 528 on Page 19

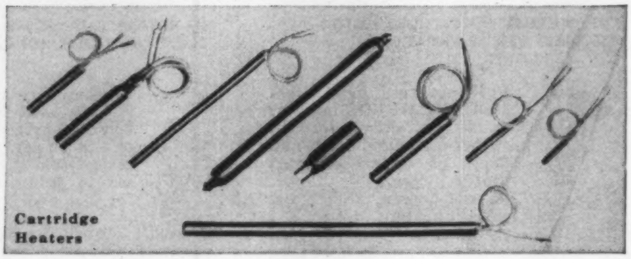
Call your CHROMALOX Man for the heating answers



Strip Heaters



Tubular Heaters



Cartridge Heaters

These 3 basic CHROMALOX heaters provide answers to just about any heating problem

Strip Heaters . . . that quickly and easily bolt or clamp to platens, dies, kettles, tanks, pipes, rolls, drums, ovens and air ducts. Lengths from 4 to 96 inches, widths from $\frac{3}{4}$ to $2\frac{1}{2}$ inches, with cross section curving or lengthwise bending. Available with brazed-on fins.

Tubular Heaters . . . that clamp on, fit into machined grooves, cast into metals, immerse in liquids, install in ovens and ducts. Straight lengths or factory-formed to nearly any contour. Lengths from 6 inches to 30 feet. Triangular or round cross section. Available with brazed-on fins.

Cartridge Heaters . . . that smoothly fit standard drilled holes in dies, platens, molds, extrusion and injection barrels. Special leads available for protection against flexing action, abrasion, moisture or vapors. Diameters from $\frac{3}{8}$ to $1\frac{19}{64}$ inches, lengths from $1\frac{5}{8}$ to $25\frac{3}{8}$ inches.

Versatile Chromalox electric heaters are available in sheath materials and wattages to match almost any application to 1100°F. Easy to install, they are fast, clean, safe and economical.

Each has particular advantages. Your Chromalox Man can help you determine the one that best answers your specific problem. He's backed by the world's largest factory stock of industrial heaters, ready for immediate shipment. Why not give him a call. You'll find his phone number listed at the right.

Our new Catalog 60 provides detailed product information and suggests numerous applications for the complete line of Chromalox electric heaters for industry. If you have not yet received a copy, please let us know.

7760

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Electric Heat
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Circle 529 on Page 19

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Miniature Toggle Switch

Miniaturized TM toggle switch rated 7 amp, 28 v dc resistive at sea level and at 75,000 ft measures only ½ x ½ in. at the base and weighs only 4½ grams. It is subject of Data Sheet 158. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 689 on Page 19

Rolled Steel Rings

Process by which Edgewater rolled steel rings are made from solid block of steel is explained in booklet. Diameters of these weldless steel rings range from 5 to 145 in. and weigh as high as 14,000 lb. 12 pages. Edgewater Steel Co., Box 478, Pittsburgh 30, Pa. F

Circle 690 on Page 19

High Voltage Starters

Bulletin 8130 descriptively covers high voltage starters for squirrel cage, wound rotor, and synchronous motors, in both air-break and oil-break forms, for use on 2200 to 4800-v systems. Various enclosures are described. 8 pages. Square D Co., Electric Controller & Mfg. Div., 4500 Lee Rd., Cleveland 28, Ohio. G

Circle 691 on Page 19

Acceleration Switches

Acceleration-sensitive switches with only one moving part are subject of illustrated catalog. They respond to axial, radial, or omnidirectional acceleration over a 0.01 to 500 g range. Specifications and application data are given. 4 pages. Inertia Switch, Inc., 311 W. 43rd St., New York 36, N. Y. D

Circle 692 on Page 19

Meter-Relays

How meter-relays measure and control almost any variable that can be detected electrically is explained verbally and graphically in Bulletin S-1. Features which contribute to control reliability are covered. 4 pages. Assembly Products, Inc., 75 Wilson Mills Rd., Chesterland, Ohio. G

Circle 693 on Page 19

Lubricants

Choice of the proper lubricant for practically any extreme pressure lubrication job is facilitated by Bulletin 121, a lubricant selector chart. Each Molykote lubricant is evaluated in terms of temperature, environment, method of application, and other factors. 4 pages. Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn. B

Circle 694 on Page 19

Vibration & Noise Control

Detailed discussion of the relative merits of steel springs and organic materials as isolation media is contained in Booklet K4E on 27 types of products for control and measurement of machinery vibration, shock, and noise. Specifications and installation photos are included. 8 pages. Korfund Co., 48-190 32nd Place, Long Island City 1, N. Y. D

Circle 695 on Page 19

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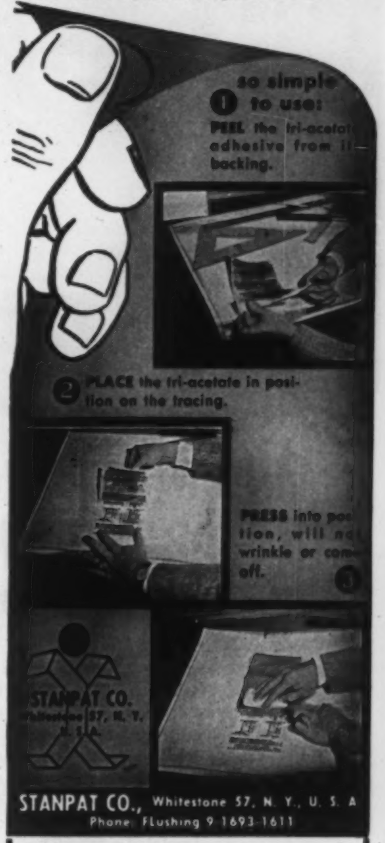
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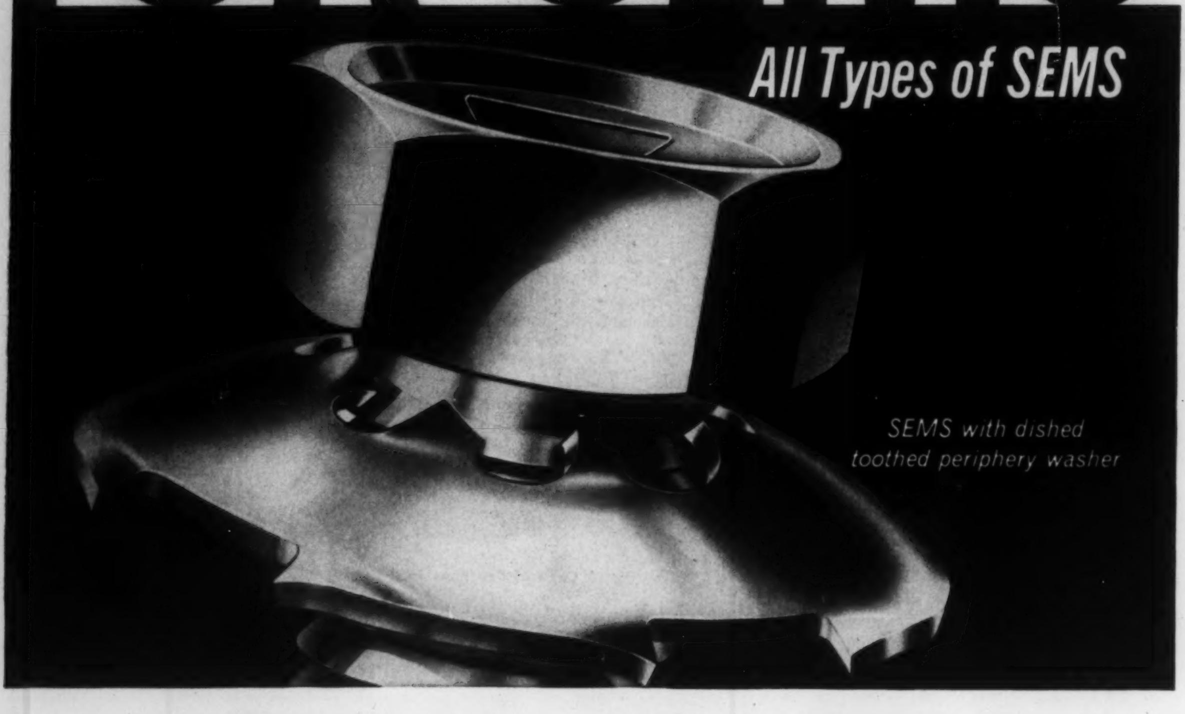
Circle 530 on Page 19

FOR SEMS



All Types of SEMS

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3 New, Improved THREAD-CUTTING Screws from P-K

The five cutting flutes on the new, improved P-K Type "F" and "BF" reduce pressure development by 80 percent! The completely formed threads on these screws have sharper cutting edges, and 5 deep flutes that are of continuous depth. These features make for better clearance of the accumulated material and assure minimum stresses in driving and avoid the possibility of stripping or galling.

"PENTAP"
THE NEW IMPROVED
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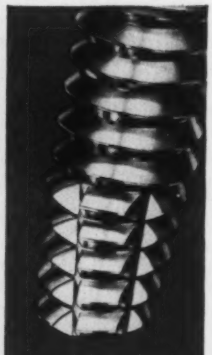

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Whatever you require in pre-assembled washers . . . SEMS, and neoprene or nylon washer STAPS® . . . in thread-forming and thread-cutting tapping screws, or machine screws . . . with slotted, Phillips or Hex heads . . . P-K can supply them all through your local P-K "Bulk-Stocking" Distributor.

P-K SEMS reach your assembly line pre-assembled, ready for instant use. Washers cannot come off—can never be mislaid or misplaced—insures washers on the screws . . . not on the floor! Double inventory and double parts handling is completely eliminated.

P-K SEMS can be hopper fed for automatic driving. Inspection rejects due to omitted lock washers are impossible—fastenings stay tight and firm. P-K Sems assure concentric washer seating.

STAPS® are standard P-K fasteners, pre-assembled with nylon or neoprene washers for effective control of leaks, squeaks, crazing and electrolysis, in all types of metal structures and assemblies.

Your nearby P-K "Bulk-Stocking" Distributor can meet your needs—any time—in any quantity. Call him for samples and complete information.

TYPE F*, the new, improved hardened thread-cutting screws have been developed by P-K for use in friable, granular or brittle material. The pilot, with its five tapping flutes, cuts a standard machine screw thread as the screw is turned in. The Type F is ideal for making fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steel, plastics and resin-impregnated plywood.

"PENTAP"**, the new, improved P-K Type B-F (formerly F-Z) combines the five thread-cutting flutes of the Type F screw with the coarse pitch, widely spaced threads of the P-K Type B. The thread-cutting "PENTAP" Type B-F distributes cutting pressure evenly, lets chips drop to the bottom of the hole, prevents cracking of material. It is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.

TYPE L† is a completely new and improved thread-cutting screw developed by Parker-Kalon for use in nylon. The Type L functions as a combination thread-cutting and thread-forming screw . . . in that it cuts a small amount of the nylon to allow the full diameter threads to form. Type L offers a particular advantage in nylon assemblies which must be disassembled for service, because *the P-K Type L can be removed and replaced without stripping or galling.*

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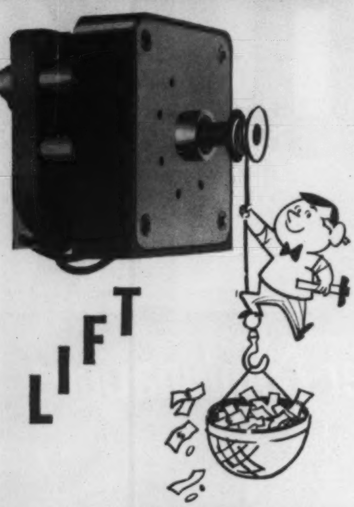

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Circle 532 on Page 19

Blind Rivets

Advantages of pull-through and self-plugging blind rivets are related in illustrated Brochure 8-409. Recommended hole sizes, material specifications, and shear and tension strength values are given and typical uses are shown. 8 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 696 on Page 19

Impulse Counters

Small panel mounted predetermining electric impulse counters are described and illustrated in bulletin. Operating principle, construction details, and dimensional and electrical data are among contents. 4 pages. Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y. D

Circle 697 on Page 19

Air Equipment

Fifty-six different items in various bore sizes, styles, mountings, and voltages are listed in Bulletin 4-59 on Minimatic miniature air cylinders, valves, solenoids, fittings, and accessories. 4 pages. Clippard Instrument Laboratory, Inc., 7390 Colerain Rd., Cincinnati 39, Ohio. G

Circle 698 on Page 19

Filter Elements

Nine basic Bendix filter elements for various air, gas, and liquid requirements are described and illustrated in Catalog BFD-48. Filtration ratings are as low as ½ micron and −65° F and up to 1200° F. Variety of materials is employed. 4 pages. Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich. H

Circle 699 on Page 19

Hydraulic Power Units

Engineering data, general description, performance data, and installation drawing are included in two illustrated bulletins (106-3 and 106-4) on Model 6605 and 6606 hydraulic power units for aircraft use. 2 pages each. Lear, Inc., Grand Rapids Div., 110 Ionia Ave. N.W., Grand Rapids 2, Mich. H

Circle 700 on Page 19

Electronic Systems

Electronic systems and components, including complete missile, drone, aircraft, and ground avionic devices, are presented in Catalog AV-100. Facilities of company for design and production of these products are outlined and explained. 40 pages. Request on company letterhead from Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif. L

Hydraulic By-Pass Valves

Details of a complete line of screw and flange type oil by-pass relief valves for pipe systems from ¼ to 3 in. and pressures to 500 psi on hydraulic service are given in "Mechanical Data Book." UL-approved valves for oil-burning equipment are also shown. Graphs and tables give design data. 16 pages. Request on company letterhead from Fulflo Specialties Co., 437 Fancy St., Blanchester, Ohio. G

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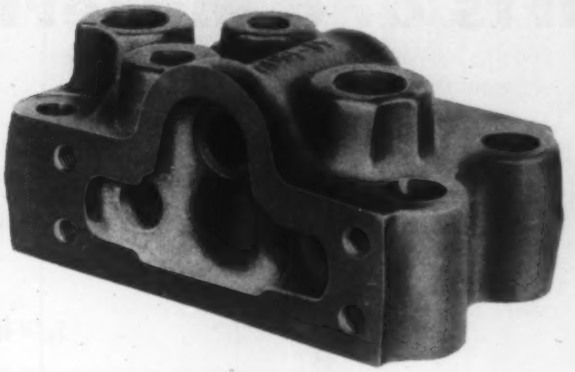

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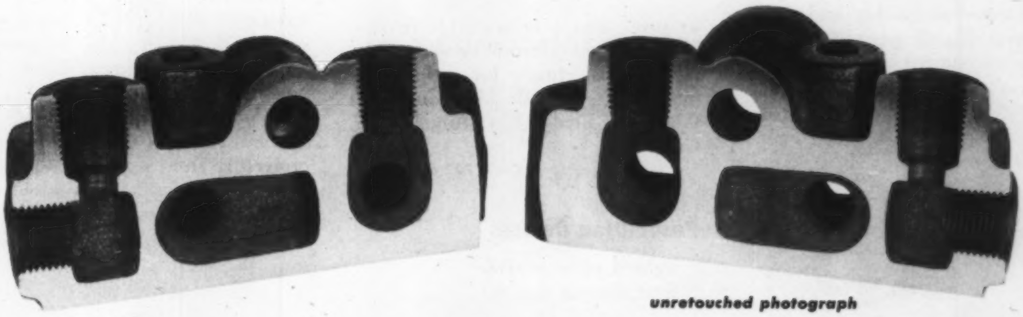

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Free Literature: Bulletin 32 — Meehanite Quality Control Assures Uniform Dependability.

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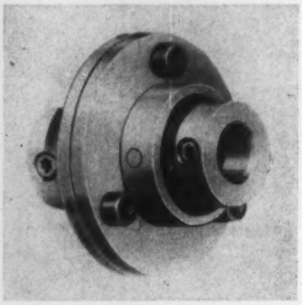
Flexible Coupling

miniature unit has ball-socket design

Miniature disconnect flexible coupling for power-transmission applications is available in bore sizes in 1/32-in. increments to ½-in. diam bore size each hub end. Coupling, designated Posiflex, permits quick installation or removal of components from equipment without removing shafting. Coupling is interchangeable so that spare parts can be installed quickly and easily. Ball-socket design permits shaft-to-shaft misalignment of 30 deg angular offset and 3/16-in. parallel offset. Unit, of stainless and alloy steel, assures tight backlash at high speeds and torque. It measures 1-3/16 in. diam by 1-1/16 in. long. **Fourdee Inc., P. O. 6006, Orlando, Fla.** O

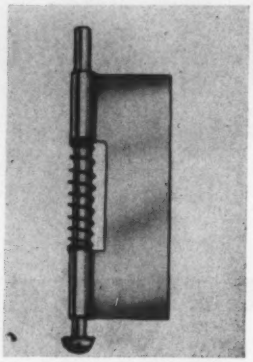


Circle 701 on Page 19

Latch Hinge

is adaptable to a variety of uses

Instant-release latch hinge is composed of a rugged housing and pin with captured spring. The multi-fit assembly is adaptable to a variety of uses. Any hinged part can be taken off or put back at a touch, and strong bearing surfaces provide easy release and action under load. Spring locks part to position when in use. Hinge is available in several standard assemblies which can be modified simply for wide range of applications. **Burklyn Co., 3429 Glendale Blvd., Los Angeles 39, Calif.** L

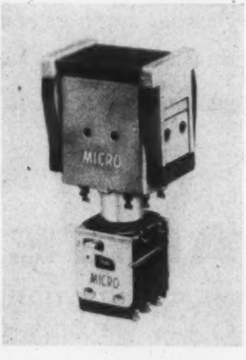


Circle 702 on Page 19

Pushbutton Devices

lighted units provide flexibility of use

Modular lighted indicator and pushbutton switch devices, termed Series 2, permit flexibility of use in modern control equipment where combined control and indicating functions are desired. Each indicator-switch assembly consists of translucent pushbutton, operator - indicator unit, lamps, and switch unit. Two mounting styles, barrier and flange mount, are available. Wide range of indicator colors and styles is available. **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.** K

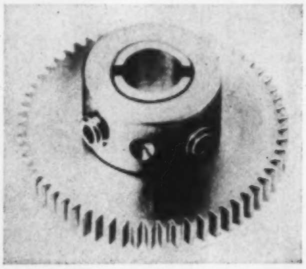


Circle 703 on Page 19

Split-Hub Gear

for breadboard and field use

Split-hub gear provides compact clamping and can be used for breadboard and field use where pinning is required. Collar has two setscrews at right angles bearing on same half of split hub. Proper pinning location is determined by spot hole midway between setscrews. Hub projects 0.010 in. beyond collar, and there is 0.010 in. shoulder projecting from opposite face, eliminating need for spacers when used against ball bearings. Gear is Precision Class 2 with 0.1873-in. bore, ±0.0003 in., has 0.10-in. face width and 72 diametral pitch. Material is 303 stainless or Alodined 2024-T aluminum, depending upon number of teeth. **Gap Instrument Corp., 116 E. Merrick Rd., Freeport, L. I., N. Y.** D



Circle 704 on Page 19

Elapsed-Time Indicator

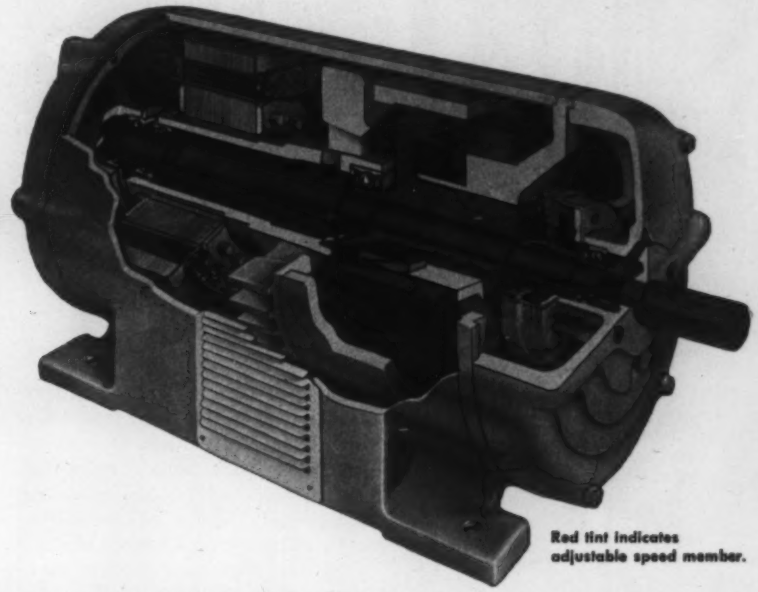
miniature unit has 1.8 billion to 1 gear train

Weighing only 3 oz and occupying a space of 1-1/16 in. OD by 1-15/16 in., WT-1 subminiature elapsed

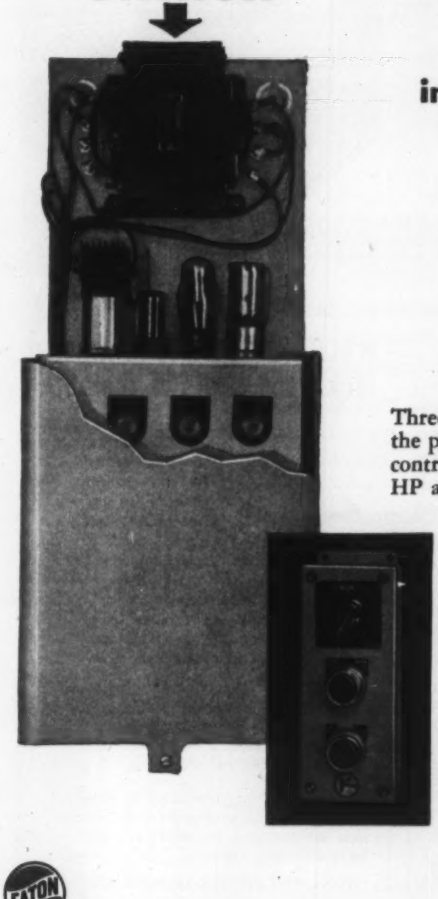
THIS NEW QUILL-TYPE AJUSTO-SPEDE® DRIVE

Plus

THIS NEW K-2 CONTROL and PUSH-BUTTON STATION



Red tint indicates adjustable speed member.



Give You Controlled Adjustable Speed from an AC Power Source

in a Compact, Low Cost 3-Unit Drive Package

by

DYNAMATIC®

PIONEER IN EDDY-CURRENT EQUIPMENT

Three compact components, the Ajusto-Spede Drive, the K-2 Control, and the push-button station make up this complete drive package which provides controlled adjustable speeds for any application from ½ HP through 7½ HP at 1800 RPM.

Remote wall mounting of the control panel conserves space on the driven machine; the push-button station places vital controls at the operator's finger tips.

Standard control features include on-off clutch control, infinite speed adjustment, constant speed regulation, and jogging. Any of a variety of special features may be easily and economically added to the standard control by the installation of a single resin-encapsulated circuit.

Send for complete information covering design and operation of the new models ACM-903 and 904 Ajusto-Spede Drives. Read how the new K-2 Control provides infinite speed adjustment, on-off clutch control, constant speed control, jogging, threading, cascading, and acceleration control.

Our New Bulletin K-2-159 is Now Available.

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Monarch Exploratory Engineering **is doing things with castings that have never been done before. New finishes like porcelain enamel on aluminum castings stimulate design thinking...open new horizons for creating new products ...for turning present products into sales leaders. New approaches in design analysis reduce secondary operations...speed production and reduce end costs. Like the P. Y. Hahn's CO_2 powered "Peacemaker .45"...secondary machining is limited to one ream and tapping four holes.**

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MONARCH ALUMINUM MFG. COMPANY
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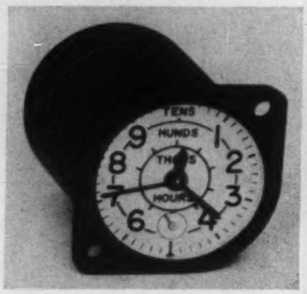
Circle 535 on Page 19



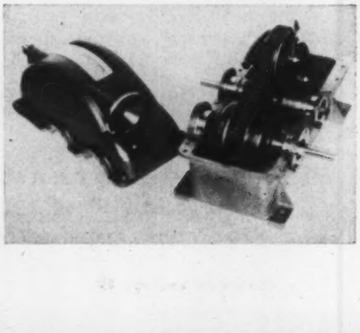
timer has total readout of 10,000 hr and is easily read to closest hour. It incorporates jewel bearings, gear train having 1.8 billion to 1 ratio, and low-inertia motor. Hermetically sealed and complying with military requirements of MIL-E-5272A, instrument requires maximum power input of only 2½ w and operates at 115 v, ± 10 per cent, at 400 cps. Synchronous speed is attained almost immediately when power is applied. **Waltham Precision Instrument Co.,** 221 Crescent St., Waltham 54, Mass. B

Circle 705 on Page 19

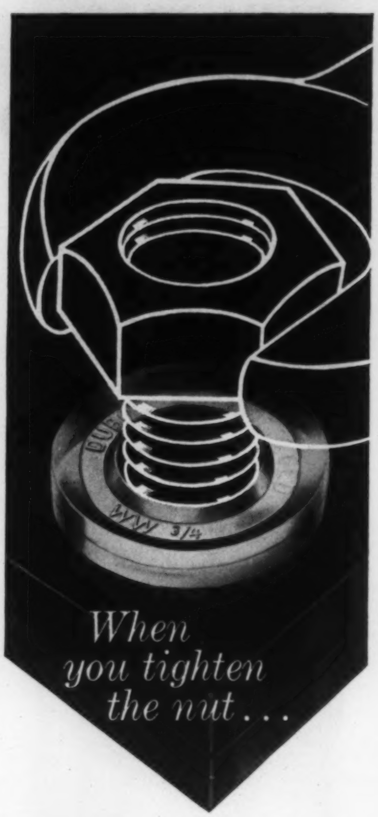
Adjustable-Speed Transmission

has ratios of
3:1 and 9:1

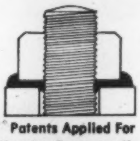
Adjustable-speed transmission, Model 19000, is designed around a combination TV-Belt providing 3:1 ratio with basically constant horsepower. Driver of belt is a timing-belt pulley which gives constant feet-per-minute travel to belt. As plate assembly is rotated away from adjustable-speed pulley, belt is drawn into faces, separating them and allowing belt to operate at a smaller pitch diameter. To adjust speed, a segment of a worm gear is mounted to an idler carrying side plates and is actuated by a worm turned by handwheel on unit or by motor. Transmission has rated capacity of 1.5 hp with input speed of 1750



This new lock and seal washer is just plain **REVOLUTIONARY...**


DUBO
WW 3/4
When you tighten the nut...

NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it... so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one incorrectly if you tried.

PLUS FEATURES: excellent electrical properties ... exceptional wear resistance ... good shock absorption ... resists corrosion, chemicals ... non-flammable ... high flexural strength.

PLUS USES: The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

YOU'LL WANT COMPLETE TECHNICAL INFORMATION.
Write today to:

NYLOGRIP PRODUCTS
445 Watertown St., Newton, Mass.-BI 4-0960
Non Metallic Fastenings of all types.

Circle 536 on Page 19

... CONTINUOUS PROCESSING -- 1960 ...

CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

DEPARTMENT N • CAMBRIDGE 6, MARYLAND

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

SOLVED: by Sandusky Centrifugal Casting

Eastwood-Nealley's chief engineer points out great size of grooved cylinder

Who else could cast this 22-ton cylinder for the world's biggest wire cloth loom?

To weave Fourdrinier wires up to 352″ wide for the world's newest and largest paper machines, Eastwood-Nealley Corp., Belleville, New Jersey, required a cylinder over 30 feet long.

Sandusky supplied this 44,685 lb. roll, centrifugally cast of SAE-1030 steel and rough machined to 363″ in length, 40⅛″ on the O.D., to be used as the backbeam on Eastwood's new wire cloth loom. Since the cylinder had to be machined with 176 extremely smooth 2″ x 2″ stirs (grooves) in which wire is wound, it had to be of *flawless quality*. Otherwise any voids or inclusions exposed by machining would nick the delicate bronze strands and cause the expensive wire cloth to fail.

Eastwood-Nealley's chief engineer, Clemson A. Bower, asserts: "*We chose a Sandusky Centrifugal Casting because only Sandusky could make such a gigantic cylinder without welding. We were confident that our special machining operation would be accomplished without costly re-makes, for in the 12 years we have been using them, we never found a single flaw in a Sandusky Centrifugal Casting!*"

When cylinders or piping are needed in your design, keep Sandusky Centrifugal Castings in mind. We can supply cylindrical products from 7″ to 54″ O.D. and up to 33 feet long—made from a variety of alloys including stainless, carbon and low-alloy steels as well as copper- and nickel-base alloys. Send for free booklet, "Your Solution to Cylindrical Problems."

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

9804

SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

Circle 539 on Page 19

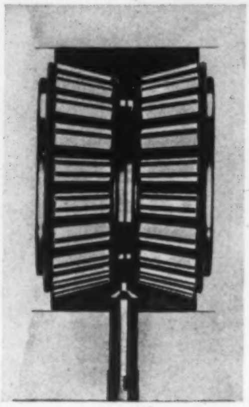
rpm and has 3:1 over-all ratio. Increased over-all ratios of 9:1 can be obtained by adding an auxiliary gear box of 1:1 and 3:1 ratios. Transmission requires no internal lubrication and can be operated in horizontal, vertical, angular, inverted, or any other position. **Western Mfg. Co.**, 3400 Scotten Ave., Detroit 10, Mich. H

Circle 706 on Page 19

Double-Cup Bearings

are pin-type units

Double-cup bearings have been developed primarily for applications where bearings are used with loose cup fits, unclamped in floating positions, and where a cup-locking device is desirable. Hollow pin located in housing fits into large countersunk hole in cup OD. While pin prevents cup from turning in housing, it does not restrict axial float. Design insures positive bearing lubrication by introducing lubricant through hollow pin direct to center of bearing. Units are dimensionally interchangeable with other Timken double-cup bearings. Several methods of pinning cups are possible. **Timken Roller Bearing Co.**, Canton 6, Ohio. F



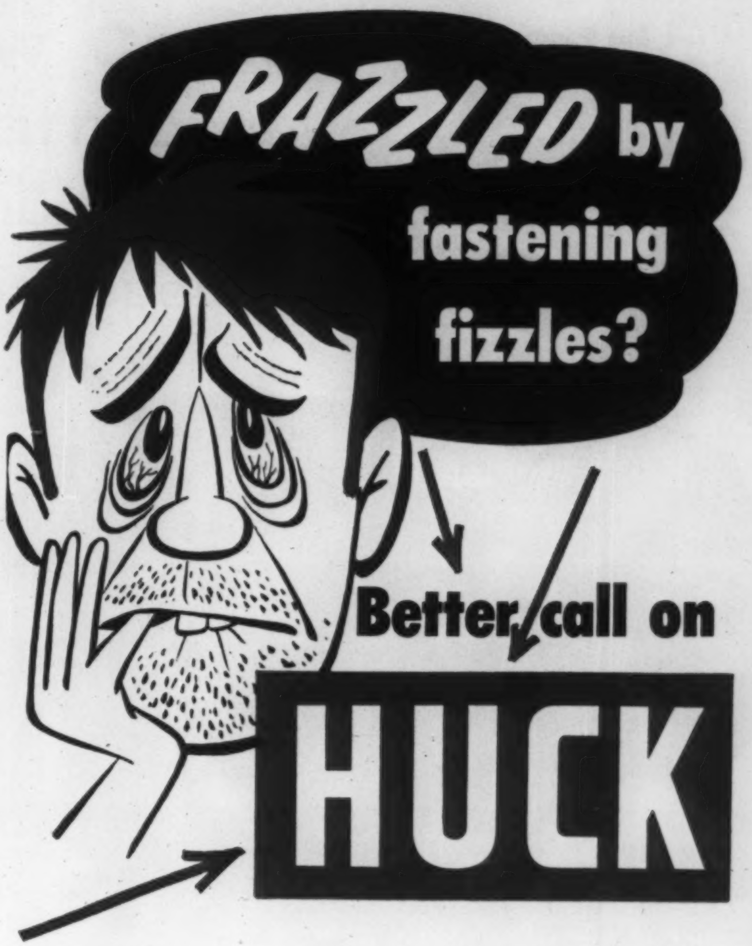
Circle 707 on Page 19

Hydraulic Coupling

incorporates swivel breakaway frame

Push-pull coupling is designed for easy connection and disconnection on hydraulic systems with working pressures to 3000 psi. It seals positively when either connected or dis-

(Please turn to Page 216)



HUCK means more than just good fasteners. It's a complete, well-tested system that affords efficiency, flexibility, and economy to many of the country's leading manufacturers.

The reason for Huck's superiority is simple. An intensive continuing development program that produces the "last word" in fasteners for your every requirement, in standard or exotic metals.

An aggressive tool development program that has produced simple, sturdy, lighter weight installation tools that will produce uniformly "skilled" quality fastenings in the hands of "unskilled" operators, with less fatigue.

A thoroughly experienced staff of fastening engineers who will carefully analyze your problem and give you accurate advice for its solution.

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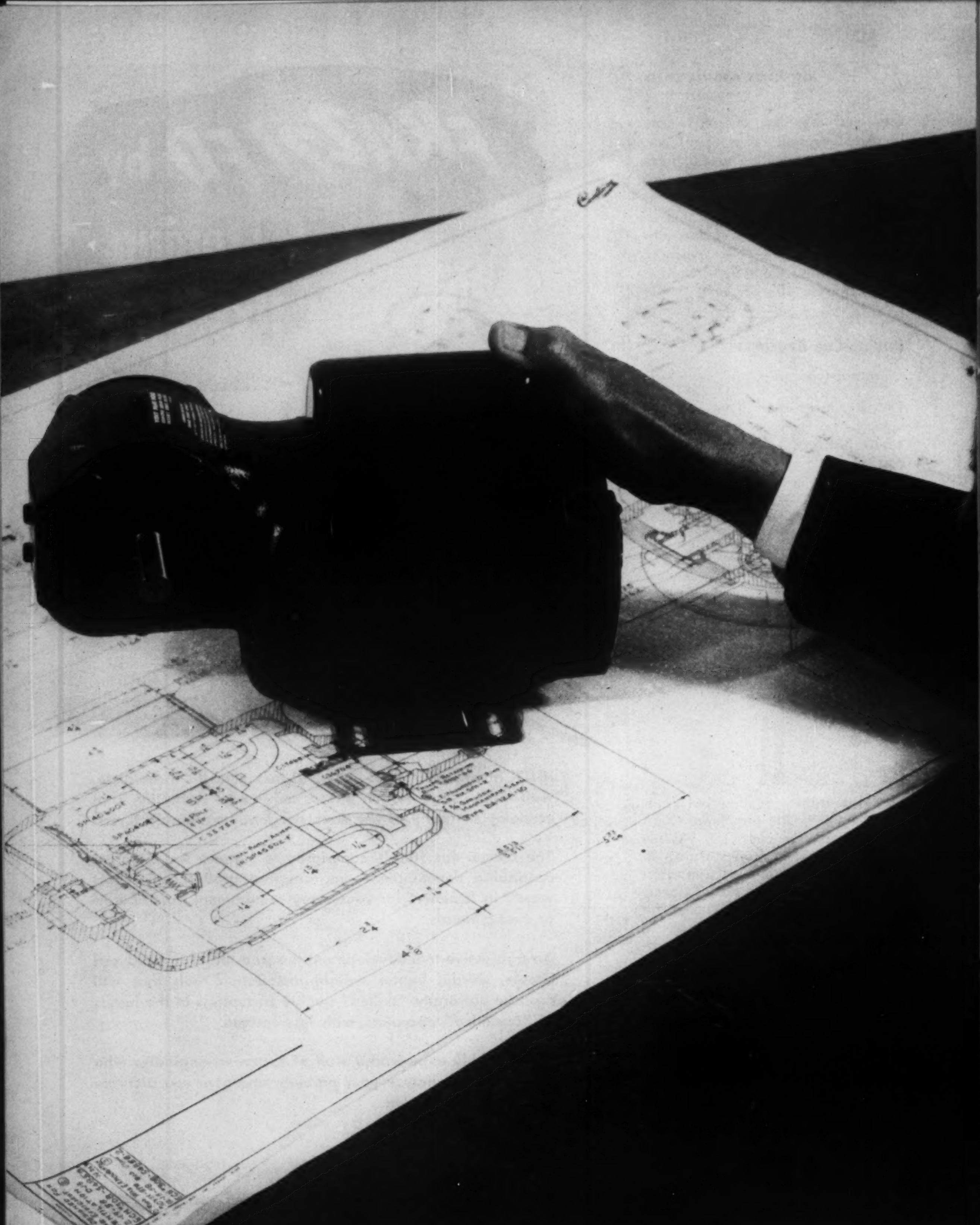
Circle 540 on Page 19



New Century Electric single-reduction, right-angle gear-motor is smaller, lighter and more versatile than ever.

New Century Electric Gearmotor

combines compactness with dependable power

Looking for a small gearmotor that is light and compact—yet able to handle heavy thrusts and the shock of sudden overloads? This new Century Electric single-reduction, right-angle shaft gearmotor may be the answer. Here are the facts:

Smaller and lighter. You can cut as much as 20 pounds from the weight of any product . . . in the ⅛ hp size, for example, this gearmotor weighs only 23 lbs. New insulating materials and new designs make more compact motors . . . new gearing and oil seal systems make gear housing smaller. Result: savings of about 50 percent in overall size.

Dependable power. Both motors and gearhead are built by Century Electric . . . means this gearmotor is backed from one source. Single-phase motors include capacitor start and split phase types. Polyphase motors are squirrel cage design.

Little or no service is needed because of features like:

High quality gear system—Worm gear is made of tough silicon bronze. Worm is made of hardened, high-grade steel. Both can withstand sudden shocks and overloads.

Dependable sealing system—No oil can get from gears into motor and cause costly shutdowns. A face-type seal with spring backing is used on the high speed shaft. A lip-type seal is used on the low speed shaft.

Output-shaft roller bearings—Roller bearings on output shaft provide reserve strength so motor can handle heavy radial and thrust loads and sudden shocks of overloads. Bearings are precisely aligned so worm and worm gear operate efficiently and quietly.

All-angle oiling—No matter at what angle motor is mounted, the worm or worm gear is always dipping in oil—so gears are always well lubricated. Means less wear and longer life.

Versatile mounting. You have complete freedom in mounting. Here's why. The gearhead can be assembled in four different positions in relation to the motor (the diagram below shows three of these positions) . . . shafts can extend from either or both sides of the gearhead . . . oiling and sealing systems make it possible to install gearmotor at any angle.

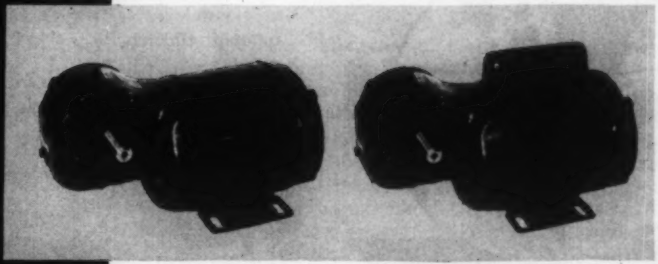
You can get more information from your nearest Century Sales Office or Authorized Distributor. Variations are available to fit specific design needs. For a copy of the new Century Electric Motor Application Guide, write for bulletin 270A.

CENTURY ELECTRIC COMPANY

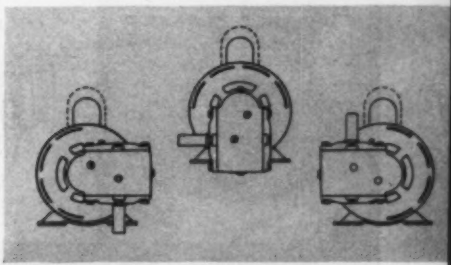
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century

59-12

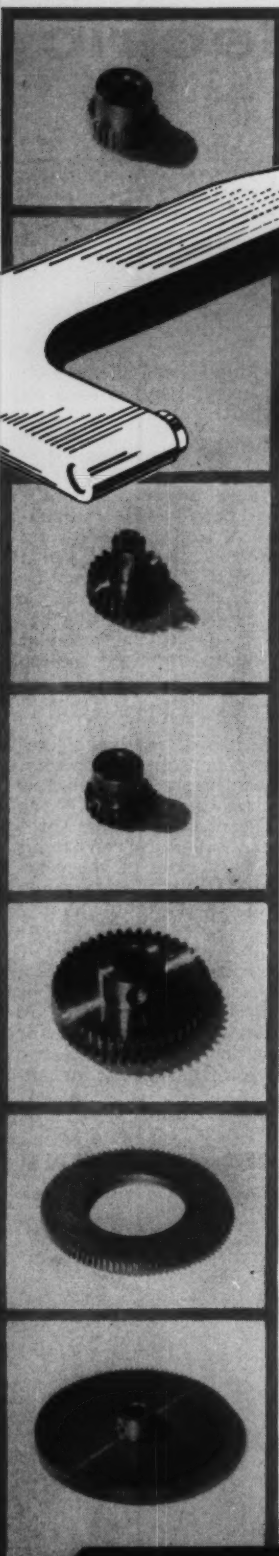


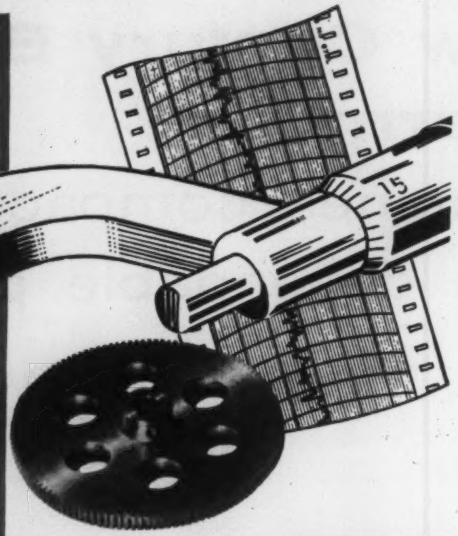
Both polyphase motors and single phase, capacitor start motors are available in the new Century Electric gearmotor.



Three of the four possible mounting positions of gearhead . . . shaft can be extended from opposite side in all cases.

Circle 541 on Page 19





YOU CAN ALWAYS DEPEND ON

Certified

APPCO PRECISION STOCK GEARS

Precision gears of all types, pitches and sizes right out of stock. Each certified for accuracy . . . each meets or surpasses A. G. M. A. specifications.

APPCO Certified Precision Stock Gears are offered in 32, 48, 64, 72, 96 and 120 diametral pitches of 14½° and 20° pressure angles. Each gear is completely sealed on a shipping tray with a plastic cover . . . always "factory-fresh," free of dust, corrosion, and scratches.

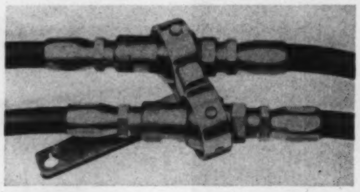
APPCO Precision Gears are engineered and manufactured to allow for accurate assembly of precision units . . . held to tolerances that assure precise fits to standard instrument bearings, shafting, etc. according to accepted industry practice and A. G. M. A. specifications. For complete technical data and catalog write to Atlas Precision Products Co., Castor and Kensington Aves., Philadelphia 24, Pa.

APPCO

Division of
PRUDENTIAL INDUSTRIES INC.

Circle 542 on Page 19

(*Continued from Page* 213)



connected, and allows full fluid flow with negligible pressure drop. Three variations are available to meet special requirements on various types of equipment. Swivel breakaway frame for use with coupling simplifies mounting and alignment problems. Installed in the frame, coupling can swing 30 deg in any direction, virtually eliminating side thrust as a source of coupling wear and leakage, since coupling always pulls away exactly parallel to pull. **Aeroquip Corp.**, Jackson, Mich. H

Circle 708 on Page 19

One-Component Adhesive

bonds porous and nonporous surfaces

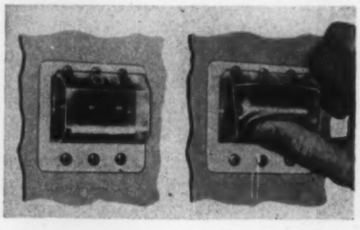
Providing exceptional strength at 300 F and above, Hysol 2527 is a smooth, thixotropic paste that will not flow during cure, even when applied to vertical surfaces. The one-component adhesive is 100 per cent solids and bonds both porous and nonporous surfaces. Viscosity is carefully controlled, and batch-to-batch uniformity is guaranteed. Adhesive film has a slight resiliency, insuring against cracking during thermal shock. **Adhesives Div., Houghton Laboratories Inc.**, 322 Bush St., Olean, N. Y. N

Circle 709 on Page 19

Flexible Covers

of glass-clear molded silicone

Rubrglas-Seels are transparent, flexible covers made of tough, clear



World's first "screech-free" tires! Butyl rubber makes possible

REVOLUTIONARY NEW TREAD DESIGNS

Now Enjay Butyl rubber for tires makes possible radically improved tread designs. Tire designers are now able to minimize grooves, put more rubber on the road. So effective are tires of Butyl, they stop faster on wet surfaces than ordinary tires do on dry.

Tires of Butyl refuse to squeal on any corner, at any speed. And because of Butyl's higher damping factor, they give a smoother, quieter ride on any surface practically eliminating the thumping of road seams. They resist sunlight, ozone and weathering, are virtually immune to cracking and crazing.

Butyl, now used in over 100 automotive parts, has proved its outstanding resistance to sunlight and weathering, impact, tear and abrasion, electricity, gases, and moisture. The versatility of Butyl serves designers more usefully—to improve the performance of existing products, and to develop many new ones. Let us tell you how Butyl can help you make a better product.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

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ENJAY®
BUTYL

Circle 543 on Page 19

MAGNETS
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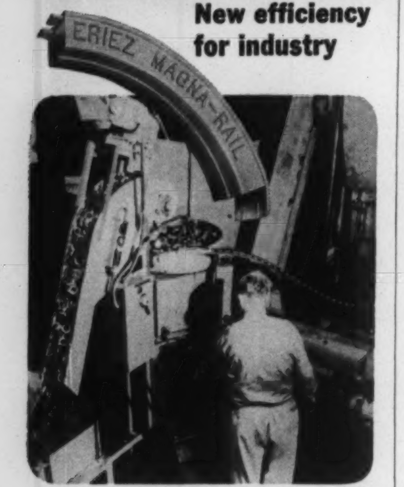
EQUALS
MAGNAmation®

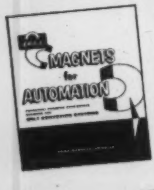
New word from
ERIEZ

New efficiency
for industry



MAGNA RAILS. Lifetime powered, non electric magnetic elements that convert ordinary belt conveyors to *magnetic* conveyor elevators. Will convey ferrous items up inclines as steep as 90° – quickly, safely, with positive hold. Easily installed under existing lines, or incorporated into new equipment. Increases production. Reduces manpower needs. Saves valuable factory floor space.

VERSATILE MAGNA RAILS ARE AVAILABLE IN MANY MAGNETIC STRENGTHS IN VARIOUS BOLT-TOGETHER LENGTHS AND IN STRAIGHT AND CURVED SECTIONS, ASSURING YOU PROPER UNITS FOR SOLVING YOUR HANDLING PROBLEMS REGARDLESS OF SIZE OF PARTS.



We work closely with design engineers, OEMs, etc. Contact us any time.

FREE! Comprehensive "Belt Conveyor" portfolio. Complete info on magnetic components, applications, test data, installation photos, etc. Write today to Eriez Manufacturing Co., 131-TA Magnet Dr., Erie, Pa.

ERIEZ

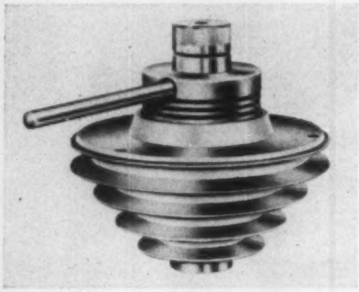
Circle 544 on Page 19

silicone. Material has an elongation of 500 per cent, temperature range from −160 to +500 F, and is resistant to acids, ozone, and sunlight. Material is molded into flexible windows, lenses, or transparent bellows to cover switches, control panels, and other moving parts. Visual inspections and mechanical adjustments can be made on hot or cold mechanical and electrical devices without exposing controls or removing seal. **Rubrglas Dept., APM Corp.,** 252 Hawthorne Ave., Yonkers, N. Y. D

Circle 710 on Page 19

Speed Reducer

gearless unit provides
precise torque control



Low-cost ball-transmission speed reducer, designated Torque-Master, contained within a four-step, V-type pulley, makes any motor a speed-reduction unit. It can be operated as a 3:1 speed-reduction unit, or locked in direct drive for delivery of full rpm of motor. In addition to offering speed reduction with accompanying torque multiplication, unit provides precise torque control. Direct-reading dial, calibrated in inch-pounds, can be set for maximum torque desired. Reducer is available with 5-in. diam pulley for shafts from $\frac{1}{2}$ to $\frac{5}{8}$ in., and 6-in. diam pulley for $\frac{1}{2}$ to $\frac{3}{4}$-in. shafts. **Roberts Aircraft Engine Co.,** 203 N. Lake St., Burbank, Calif. L

Circle 711 on Page 19

Quick Coupling

uses steel lock pins
to eliminate brinelling

Roto-Lock quick coupling is available for handling industrial liquids or exotic fuels for aircraft applications. Coupling clicks into locked

PUZZLED
about
MAGNETIC
MATERIALS

ERIEZ
uses all of them!

Confused by conflicting reports concerning new magnetic materials appearing on the market? *Here's the true, impartial story:* while many of them have excellent characteristics, most of them are particularly suitable for specific jobs. It is the performance of the finished product in your specific application under all conditions that is important.

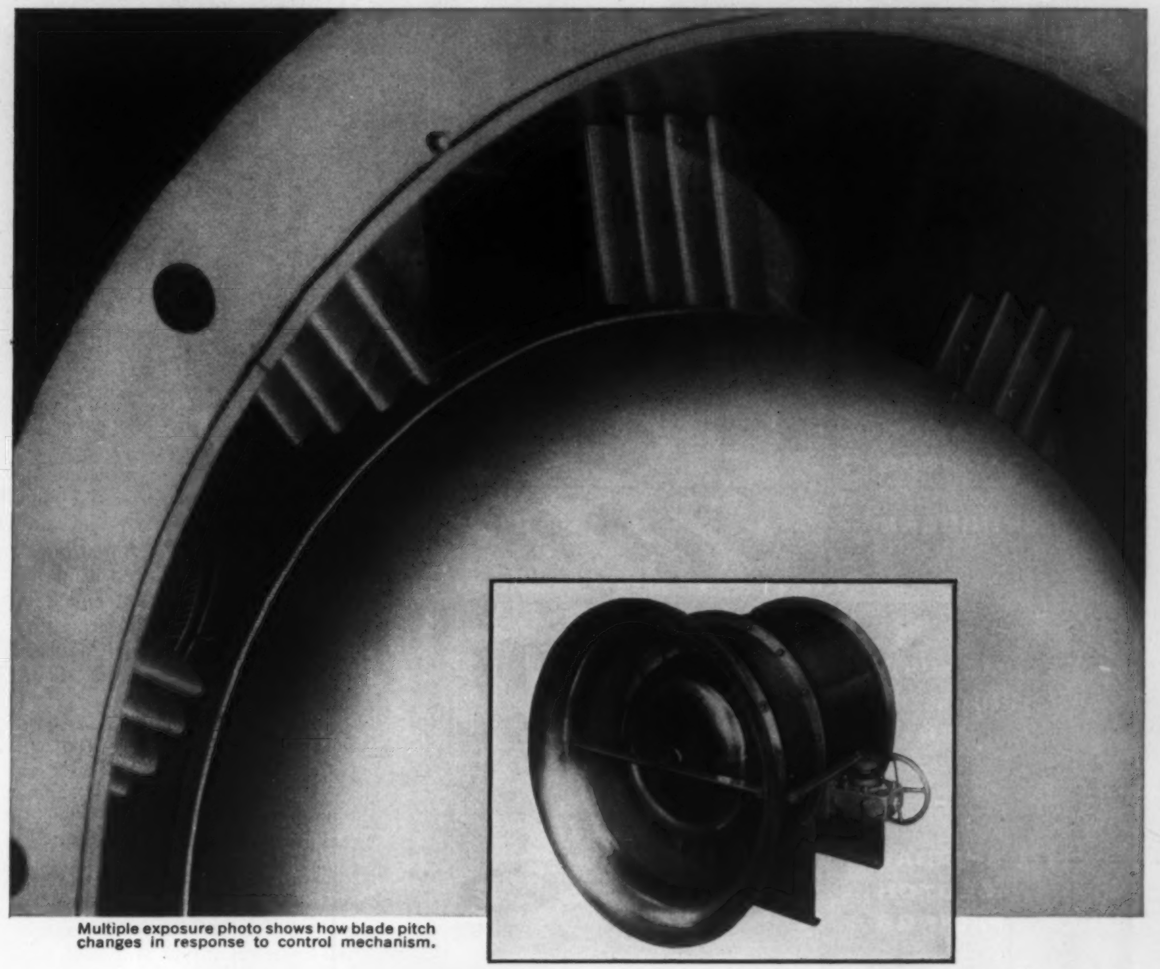
Eriez, as pioneer and world's largest producer of magnetic equipment for industry, manufactures equipment which utilizes the *best magnetic power source for your specific requirements* – at the most sensible cost to you. We do not make magnetic materials, nor are we obligated to use any special types. For that reason, we make our equipment with a variety of magnetic materials families including Alnico V, Ceramic V, Magnetic Rubber, and others. Each of these materials has certain advantages and disadvantages; we point them out when making recommendations for *your* particular needs. As new materials are thoroughly tested and proved efficient, we incorporate them into our equipment.

Whether you need a magnetic unit for tramp iron separation, microscopic fine iron separation, steel handling or conveying, or a Vibratory feeding application – Eriez has it. And because our magnetic equipment employs all types of magnetic materials, Eriez can give you the unit that will do your job *best!*

Eriez Mfg. Co., 131-TB Magnet Dr., Erie, Pa.
WRITE FOR BIG COMPREHENSIVE FACT FILE OF
MAGNETIC SEPARATION AND VIBRATION EQUIPMENT

ERIEZ

Circle 545 on Page 19



Multiple exposure photo shows how blade pitch changes in response to control mechanism.

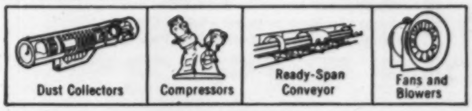
Automatic Adjustment of Air Supply to CO_2 Concentration, Temperature or Humidity with Joy Controllable Pitch Axivane® Fans

The blade pitch on Joy Axivane Fans can be changed automatically while the fan is running, varying the air volume as much as ±20%. The controlling mechanism can be linked to a sensing device to make air volume respond to a change in ambient temperature, humidity, concentration of a gas, or any of a number of conditions.

Controllable Pitch Joy Axivane Fans are ideal for ventilation of vehicular tunnels and work areas in which noxious gases tend to collect, maintaining air cooled equipment at an even temperature, stabilizing moisture content in an area, or any application requiring a variable supply of ventilation air.

Write for complete details on how Joy Controllable Pitch Axivane Fans can be made to suit your particular situation. Ask for bulletin 289-64-B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

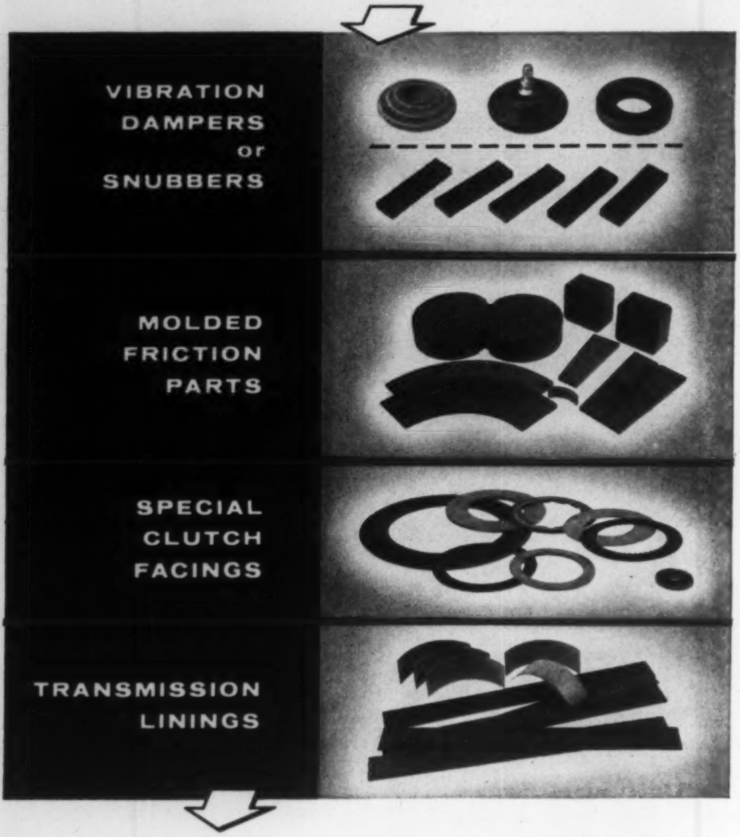
In Canada: Joy Manufacturing Company
(Canada) Limited, Galt, Ontario

WSW I 7482-289

let **WORLD BESTOS**

help you

in the design and production of



- World Bestos offers you more than 30 years' engineering and manufacturing experience in the producion of molded friction parts. Chances are our immense resources and facilities can supply you with molded parts and friction components—to meet your requirements—at a savings in both time and money.

- **Send your blueprints (or samples) for prices and delivery information to WORLD BESTOS, Industrial Products Section, New Castle, Ind., Phone: JAckson 9-4790. Write for free illustrated folder.**

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DIVISION OF THE
Firestone
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Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

Circle 547 on Page 19

ROTO LOCK
LOCK • UNLOCK
ROTO LOCK

position, and visible indicator pin drops flush with collar. It incorporates steel lock pins which permit high operating pressures and eliminate brinelling. Series 2000 (shown) and 3000, primarily for aircraft use, are available in aluminum alloy. Series 4000 and 4500 are carbon steel for all-purpose industrial use. **Roto-Lock Couplings** Inc., 4937 Firestone Blvd., South Gate, Calif. L

Circle 712 on Page 19

Spherical Bearing

has low coefficient of friction

New spherical bearing has sintered leaded-bronze outer member. It provides greater carrying capacity and lower coefficient of friction than

HEIM
LCLB-7
PAT. PEND.
U.S.A.

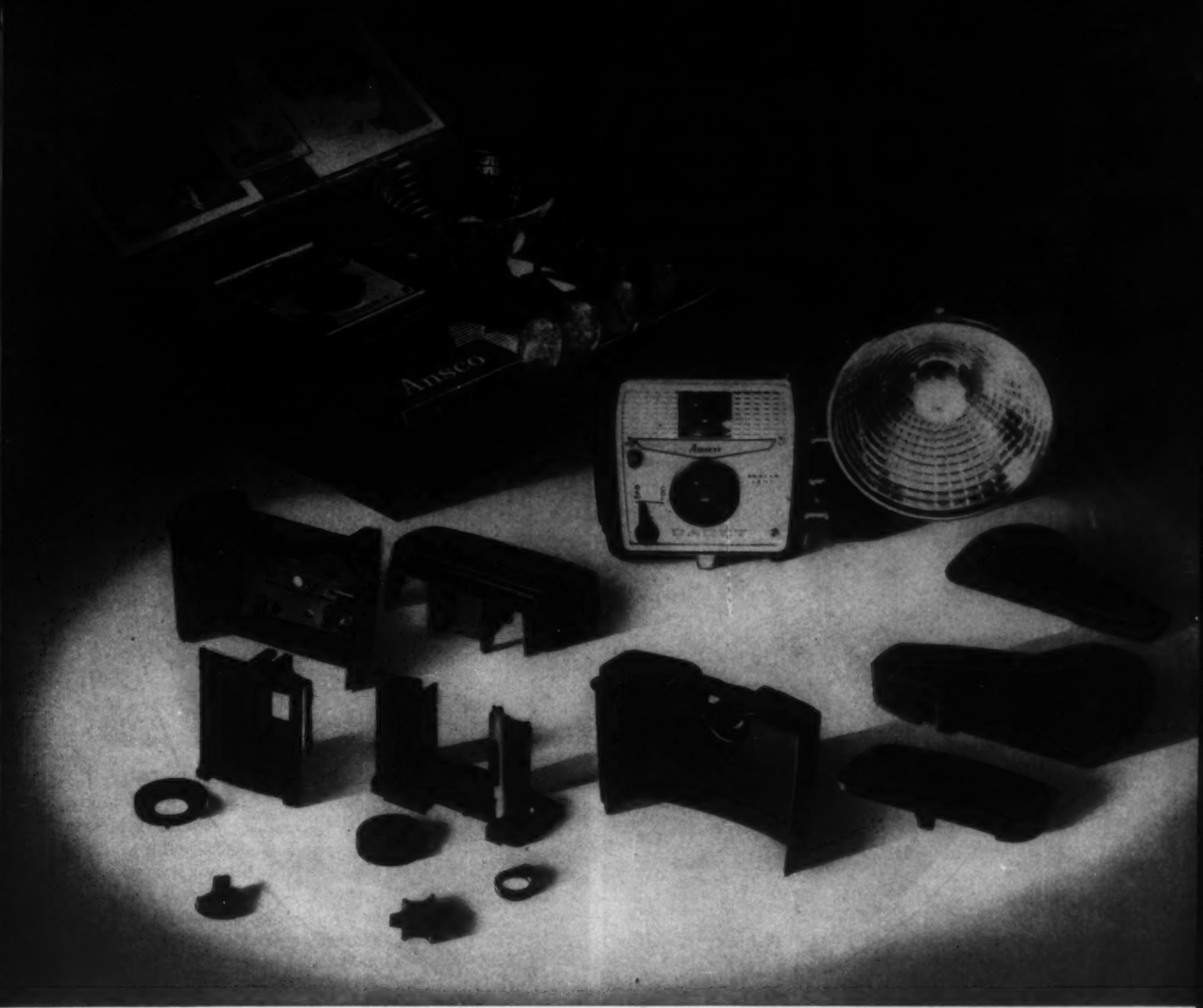
previously available with similar materials. **Heim Co.**, 20 Sanford St., Fairfield, Conn. B

Circle 713 on Page 19

Slip Ring-Brush Assembly

subminiature unit withstands 350-F temperature

Subminiature platform assembly has 50 slip rings and 100 brushes ball-bearing mounted and packaged in a dust-sealed housing only 1.25 in. long. Noise levels are consistently maintained below 50 mv, and breakaway friction level is kept under 50 gm-cm. Brushes are



Molder: Boonton Molding Company, Boonton, New Jersey.

ANSCO CADET
gets precision fit from 13 molded DYLENE® plastic parts

A low-cost camera built to last! By using DYLENE polystyrene, Ansco produces smart, yet economical plastic cameras. Each camera is assembled quickly and efficiently, because these DYLENE plastic parts are consistent in size and shape. In short: each part fits letter-perfect every time.

DYLENE is a designer's plastic. You can choose from over 15 formulations, a DYLENE polystyrene which offers you the best balance of these outstanding properties: fast moldability, high heat and shock resistance, a smooth, glossy finish, a wide range of color possibilities—and photographically opaque.

Koppers has a competent, well-trained plastics engineering staff. These men are available for discussions about your future production plans. If you are considering a new product or redesigning an old one, they will help you choose the DYLENE formulation best suited for your operation. Call your Koppers representative, he will give you the information you need.

Remember, whatever your design problem, be sure to consider DYLENE polystyrene. For more information, write to Koppers Company, Inc., Plastics Division, Dept. MD-69, Pittsburgh 19, Pennsylvania.

see our catalog in SWEET'S

Offices in Principal Cities · In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

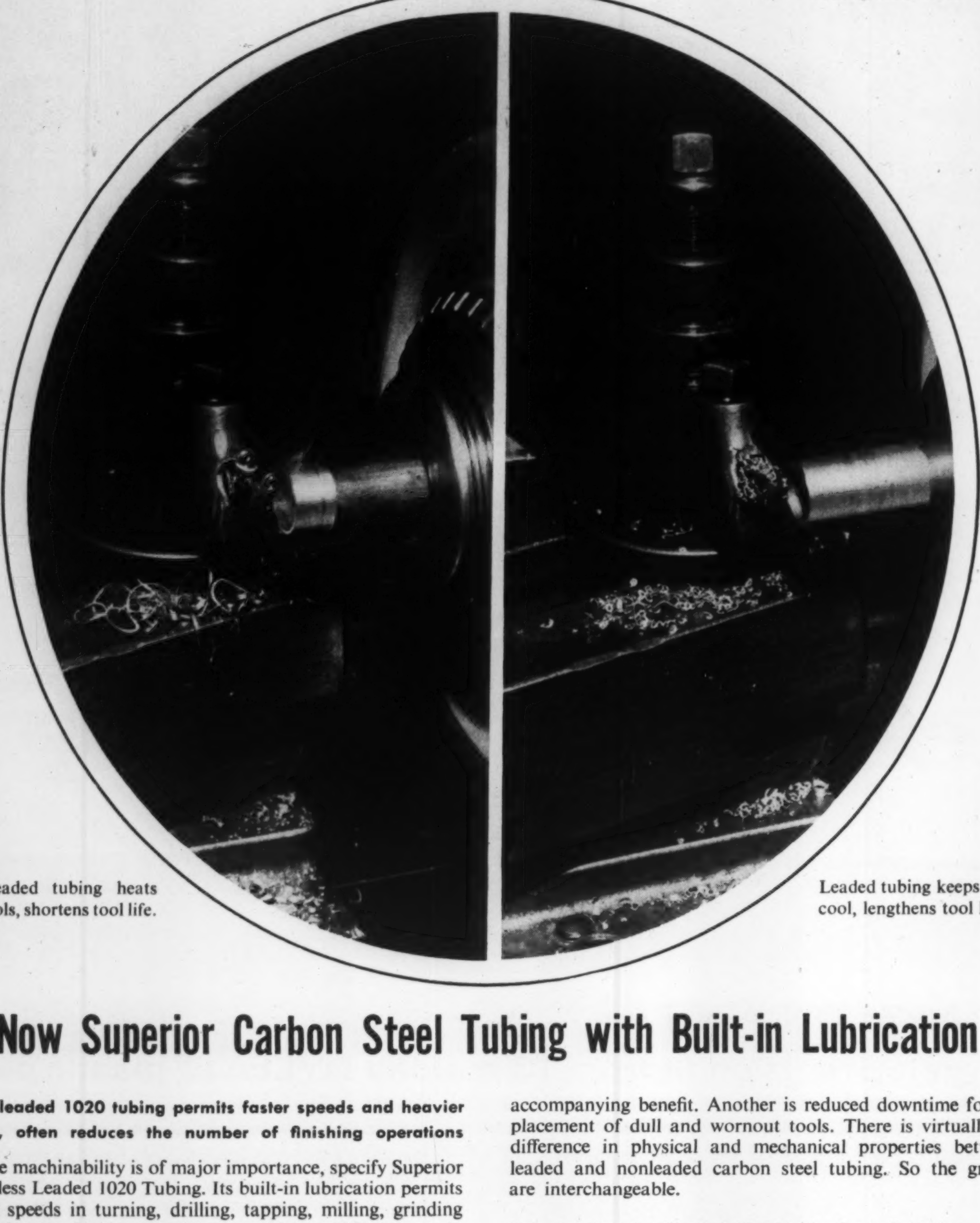
KOPPERS PLASTICS

KOPPERS

DYLENE® expandable polystyrene, SUPER DYLAN® polyethylene and DYLAN® polyethylene are other fine plastics produced by Koppers Company, Inc.

Circle 548 on Page 19

Tubexperience in action



Nonleaded tubing heats up tools, shortens tool life.

Leaded tubing keeps tools cool, lengthens tool life.

Now Superior Carbon Steel Tubing with Built-in Lubrication

New leaded 1020 tubing permits faster speeds and heavier feeds, often reduces the number of finishing operations

Where machinability is of major importance, specify Superior Seamless Leaded 1020 Tubing. Its built-in lubrication permits faster speeds in turning, drilling, tapping, milling, grinding and other machining operations, provides an 18% increase in feeds, and often reduces the number of finishing operations required to produce a smooth, lustrous surface. Build-up of metal at the cutting edge of the tool is minimized. Chip formation is improved. Tools operate at lower temperatures, last longer, and require fewer dressings. Lower tool cost is an accompanying benefit. Another is reduced downtime for replacement of dull and wornout tools. There is virtually no difference in physical and mechanical properties between leaded and nonleaded carbon steel tubing. So the grades are interchangeable.

Superior Seamless Leaded 1020 Tubing is available in a range of ODs from .012 through 1⅛ in. For particulars, send for Data Memorandum No. 24. And remember that other small-diameter tubing is available in more than 120 analyses, meeting a very broad range of applications. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

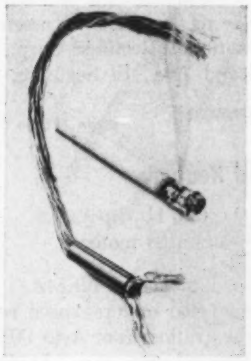
Superior Tube

The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Circle 549 on Page 19



tuned to different resonant frequencies to insure constant electrical continuity despite severe vibration conditions. Unit withstands temperatures to 350 F. **Slip Ring Co. of America**, 5456 W. Washington Blvd., Los Angeles 16, Calif. L

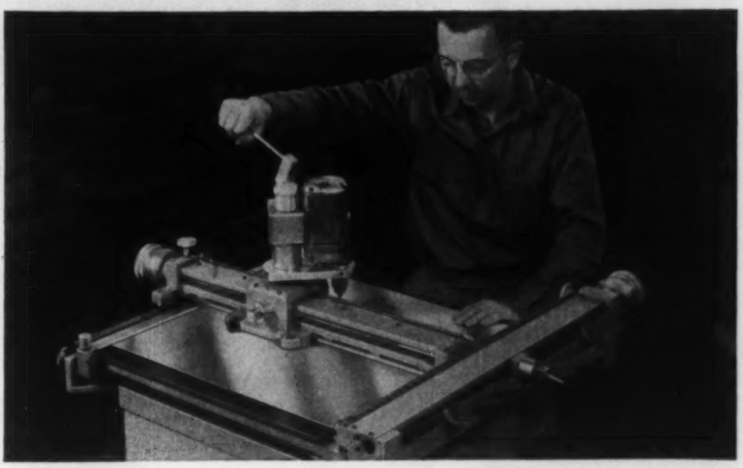
Circle 714 on Page 19

Voltage-Reference Packs

miniature units are for printed-circuit boards

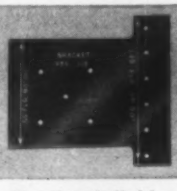
Operable directly from unregulated 28-v dc power supplies with current drain of only 30 ma, miniature voltage-reference packs are designed specifically for printed-circuit-board insertion. They provide stable reference voltages on such applications as aircraft instrumentation systems, regulated power supplies, and guidance control systems. Units provide output voltage of 8.4 v, ±5 per cent, and remain stable within ±1 mv over line variation of ±10 per cent in 28-v supply. Units can be operated up to 125 C, and feature temperature coefficient of ±0.001 per cent per deg C, from −55 to +100 C. Stable value is achieved by use of a self-contained zener diode current regulator. Each unit is completely encapsulated in an epoxy housing 1¼ x 1 in. diam. Wire leads at base of package facilitate insertion on etched circuit

layout and template making time cut in half . . .



THE NEW **STRIPPIT FLEX-O-DRILL**

- **DRILLS, REAMS, SCRIBES, CENTER PUNCHES** to ± 0.002" WITHOUT base line drawing or height gauge layout!
- **EASY, ACCURATE POSITIONING**—quickly set to any reference point and to nearest 0.100" by adjustable steel tapes reading in both directions from zero. Micrometric gauges then bring settings to nearest 0.001". No optical scanning device needed.
- **LASTING ACCURACY!** Table is an actual ground surface plate. Bridge assembly is of heavy, accurately machined castings. Lead screws are precision ground and engaged only during micrometric gauge settings to minimize wear. All parts are corrosion-resistant. Bearings are protected against dust and chips by felt shields. Drill motor is heavy-duty industrial type.
- **¼" CAPACITY** in mild steel — stock up to 24" width, any length.
- **ALSO A PROVEN MONEY-SAVER** on pilot runs, low unit production.



Template drilled by Flex-O-Drill

Layout scribed by Flex-O-Drill

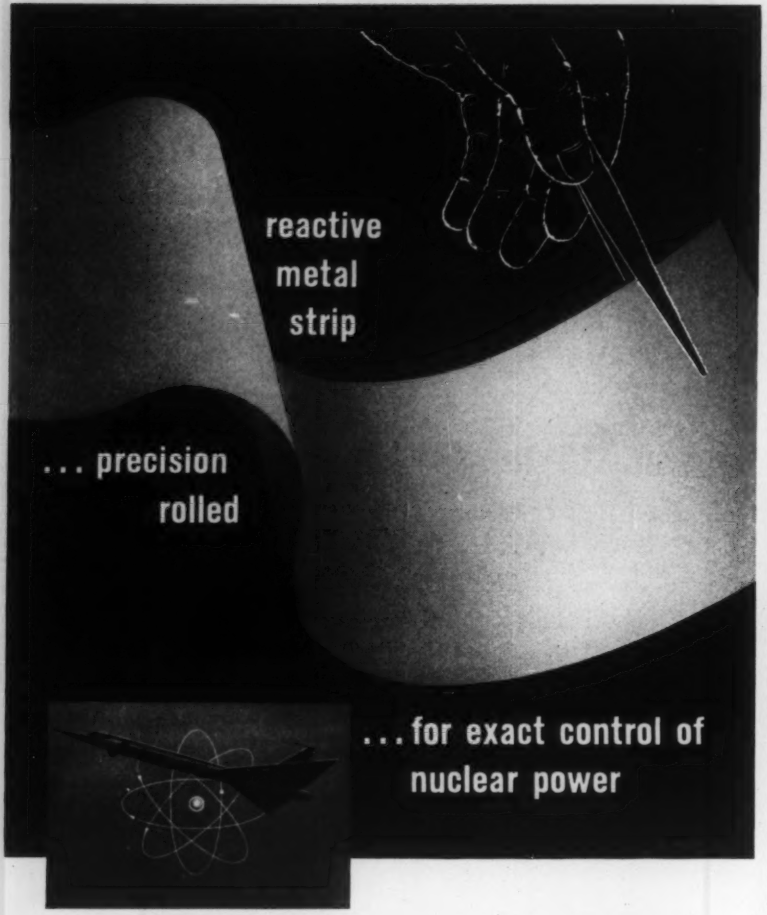
Flex-O-Drill work piece

WRITE FOR LITERATURE TODAY, and an actual demonstration at your plant:

WALES STRIPPIT INC.
216 Buell Road, Akron, New York
In Canada: Strippit Tool & Machine Company, Brampton, Ontario

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Circle 550 on Page 19

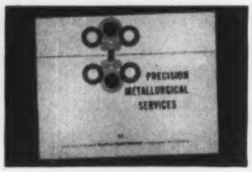


The vital need for uncommon **new** metals for nuclear applications is being met today by Precision Metals Division of Hamilton Watch Company. Now, even reactive and refractory metals such as Hafnium, Zircaloy, Tantalum, Columbium and Titanium can be obtained in any form—from ingot to ultra-thin strip and foil—in production quantities.

The newly expanded and completely integrated facilities of Precision Metals Division are geared to produce ultra-thin strip and foil in any quantity and in a wide range of alloys, with these special advantages:

thickness from .010" to .0001"
extremely close tolerances
dimensional uniformity
controlled metallurgical properties
excellent surface characteristics

For special requirements in development or production, Precision Metals can also furnish special alloys to your own specifications in the form you need. Write today for fully illustrated facilities booklet MD-6.



HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

Circle 551 on Page 19

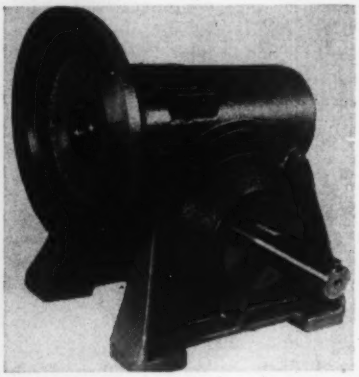
boards in production assemblies. **International Rectifier Corp.,** 1521 E. Grand Ave., El Segundo, Calif.
L

Circle 715 on Page 19

Speed Reducer

for 1/20 to 1½-hp
face-mounted motors

Designed to accept NEMA Type-C face-mounted motors, speed reducer has gear ratios from 4 to 90:1, depending on horsepower. Horsepower ranges from 1/20 to 1½ hp. Unit is furnished in three sizes, and is available with or without motor. Single-phase, three-phase, and dc motors are furnished. **Janette Electric Mfg. Co.,** Lehigh Avenue at Main, Morton Grove, Ill.
J



Circle 716 on Page 19

Thermocouple Wire Cable

is insulated with
Teflon-FEP resin

Waterproof, heat-resistant, chemically inert extrusion of Teflon-FEP is used to insulate thermocouple and extension wire cables. Insulation properties include: Low dielectric losses and high dielectric strength over wide range of temperatures; thermal stability to 200 C in continuous service, and toughness and strength over a temperature range from −200 to +225 C; resistance to all known chemicals except alkali metals under certain conditions, fluorine at elevated temperatures, and complex halogenated compounds such as chlorine trifluoride; virtually unlimited life under severe environmental conditions. Cable is available in lim-

AE

TO ENGINEERS

concerned with inner space

When there's no space to spare in your design, consider AE Class S relays. A basic Class S measures only $1\frac{7}{16}''$ x $1\frac{3}{8}''$ x $\frac{11}{16}''$ and weighs only 2 ounces.

Or, if you need a stepping switch, we have one no larger than a pack of king-size cigarettes.

Relay or switch, they're as uncompromising in quality *and* ability as their larger brothers.

As an example: the Class S miniature has many of the features of the premium-quality Class B–including sure-footed independent twin contacts.

There's another way we can help on the space problem. AE engineers have had years of experience in devising simplified circuits with complex capabilities for automatic telephone exchanges. Could be we could show you how to save a relay or two in your design. No harm in asking.

Or, if you'd like to put the switching end of the operation in our hands, we're equipped to supply completely wired and assembled, custom-built control units *or help you develop systems* to handle anything from sequential programming to . . . you name it.

Want to get together? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. If you'd like literature ask for our Circular 1702-E: *Relays for Industry,* and the new 32-page booklet on *Basic Circuits.*

AE
CAN
DO

AUTOMATIC ELECTRIC

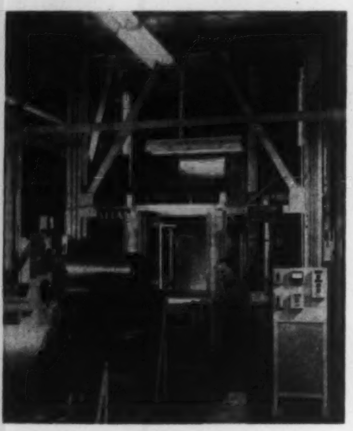
Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

Circle 552 on Page 19

THE FINISH IS ONLY THE BEGINNING

To meet demands for perfect finish on stainless and nickel Thinstrip®, Somers installs unique new annealing furnace.



This new Selas vertical continuous annealing furnace assures uncontaminated, commercially unmarred surfaces as well as uniform temper and faster delivery on stainless, nickel and nickel alloy Thinstrip up to 25" wide. But this is only part of the story of Somers' quality. Sendzimir rolling mills, Accu-Ray gauging plus 50 years leadership in thin gauge metals (from .010 down to .000125") are a few of the features Somers offers to assist you with your Thinstrip® problems.

Write for Confidential Data blank — no cost or obligation.

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Somers

Somers Brass Company, Inc.

120 BALDWIN AVE. WATERBURY, CONN.

Circle 553 on Page 19

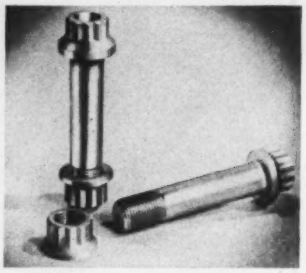
ited quantities. **Pyrometer Supplies Section, Brown Instruments Div., Minneapolis - Honeywell Regulator Co.,** Wayne & Windrim Avenues, Philadelphia, Pa. E

Circle 717 on Page 19

High-Strength Fasteners

for use in 7075-T6 aluminum or harder materials

Redesigned 220,000-psi bolts and nuts permit weight savings of 33 per cent and more in aircraft and missile design. They are for use in 7075-T6 aluminum and harder materials. Bolts are designated LWB 22, and self-locking nuts are FN 22 series. Fasteners are for applications in temperatures to 550 F, and are of 5 per cent chrome high-strength steel. They are made in standard diameter sizes of No. 10 through $1\frac{1}{2}$ in. Bolts are produced in any grip length in increments of 1/16 in. **Standard Pressed Steel Co.,** Stewart Ave., Jenkintown, Pa. C



Circle 718 on Page 19

Solenoid Valve

four-way unit has two internal moving parts

Corrosionproof, four-way solenoid valve has full $\frac{1}{8}$-in. orifice (0 to 300 psi) to 3/16-in. orifice (0 to 90 psi). Valve has only two internal moving parts and completely protected solenoid coils. Coils are sealed from air, oil, gas, and water, and will not overheat on continuous duty. Coils for continuous or intermittent duty, ac or dc, are interchangeable. Unit has long life, and replacement of one-piece valve plungers provides longer life. Plungers can be replaced without disturbing rigid piping. Adjustable flow control and manual over-ride are available. Valve can be bottom drilled for manifolding

BEARINGS WEARING EXCESSIVELY?

try low cost LISLE Magnetic PLUGS

Abrasive ferrous chips from original machining, plus particles that are constantly flaking off working parts, cause unnecessary wear to bearings, bushings, and other precision components.

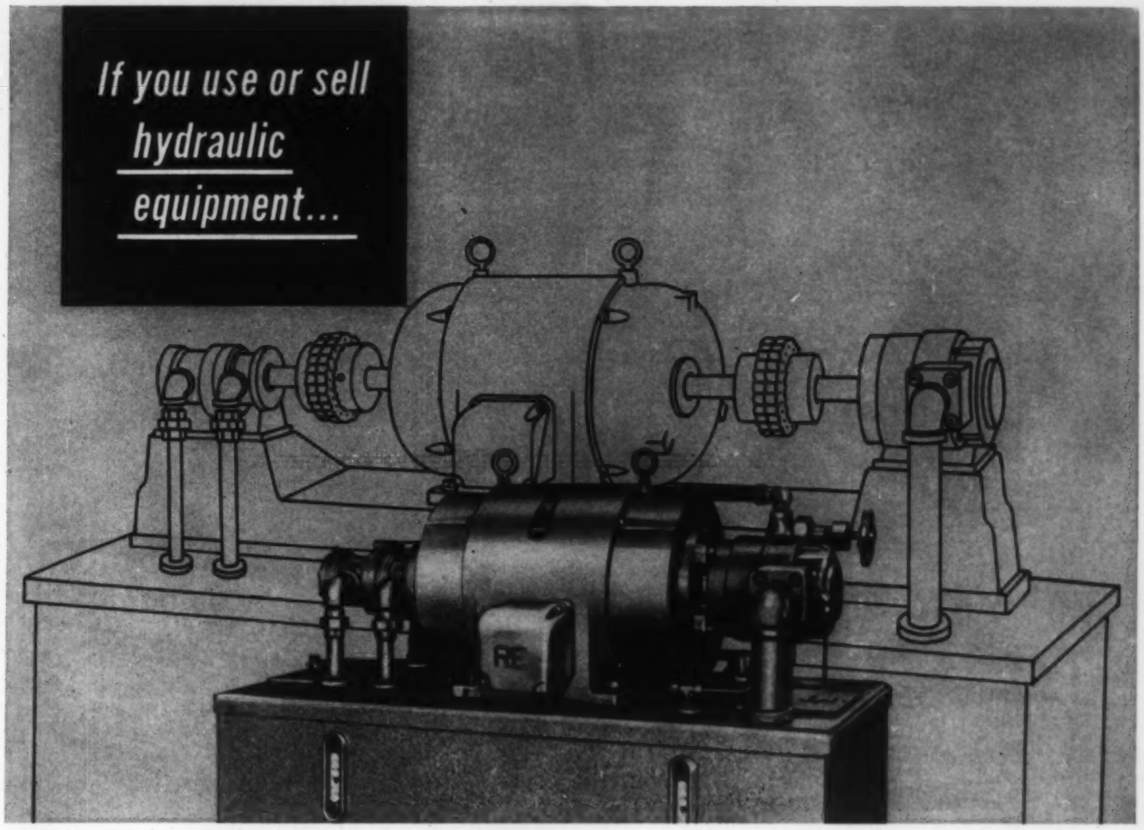
You can prolong the service-free life of your product, and increase customer satisfaction, by installing LISLE MAGNETIC PLUGS in place or ordinary drain or fill plugs.

LISLE MAGNETIC PLUGS attract and hold these chips and particles—materially reducing wear.

Write for catalog and test samples

LISLE
CORPORATION
Clarinda, Iowa

Circle 554 on Page 19



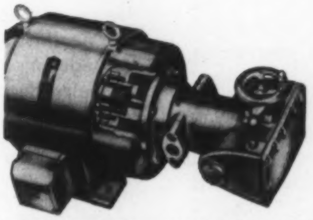
...specify REULAND spline-coupled pump mount motors

...CUT SPACE NEEDS ALMOST 50%...AVAILABLE *NOW* IN ½ H.P. THROUGH 50 H.P.!

Pump and motor become *one* with the new Reuland spline-coupled hydraulic pump hook-up. The pump shaft is connected directly to the motor's shaft *inside the motor.* Flexible couplings are eliminated... pump mount platforms are eliminated... and the tank length can be reduced because almost 50% less mounting area is required. Compact appearance is beautiful.

SPEEDY INSTALLATION

Pump-to-motor hook-up is merely a matter of seconds. All you do is slip the spline coupling onto the pump shaft...and attach the pump to the endbell. This spline coupling is supplied with the motor and is precision mated for each make of pump. There's no time wasted tinkering around... takes only a fraction of the ordinary time.



PRECISION ALIGNMENT

Alignment is perfect *automatically* whether the installation is made out in the field or on the production line. This permits even unskilled workmen to handle this simple task without error. Also, by hooking the pump up at the point of bearing support, within the motor, vibration is reduced to a new minimum. Operation is smooth, quiet.

COSTS LESS...SAVES INSTALLATION LABOR... FITS ALL PUMPS...FILLS ALL POWER NEEDS—

½-50 H.P. The Reuland spline-coupled unit is priced lower than a conventional set-up ... saves you extra money by reducing installation costs. What's more, we can supply it to fit any make of pump you may be using... and to your *exact* power needs, from ½ h.p. through 50 h.p. So sure are we that it will be of help to you, we are offering to engineer a demonstration unit to your equipment, without the slightest obligation. These units are our best salesmen.

Our New General Catalog Will Come in Handy—Sent Free on Request.

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REULAND MOTORS

REULAND ELECTRIC COMPANY

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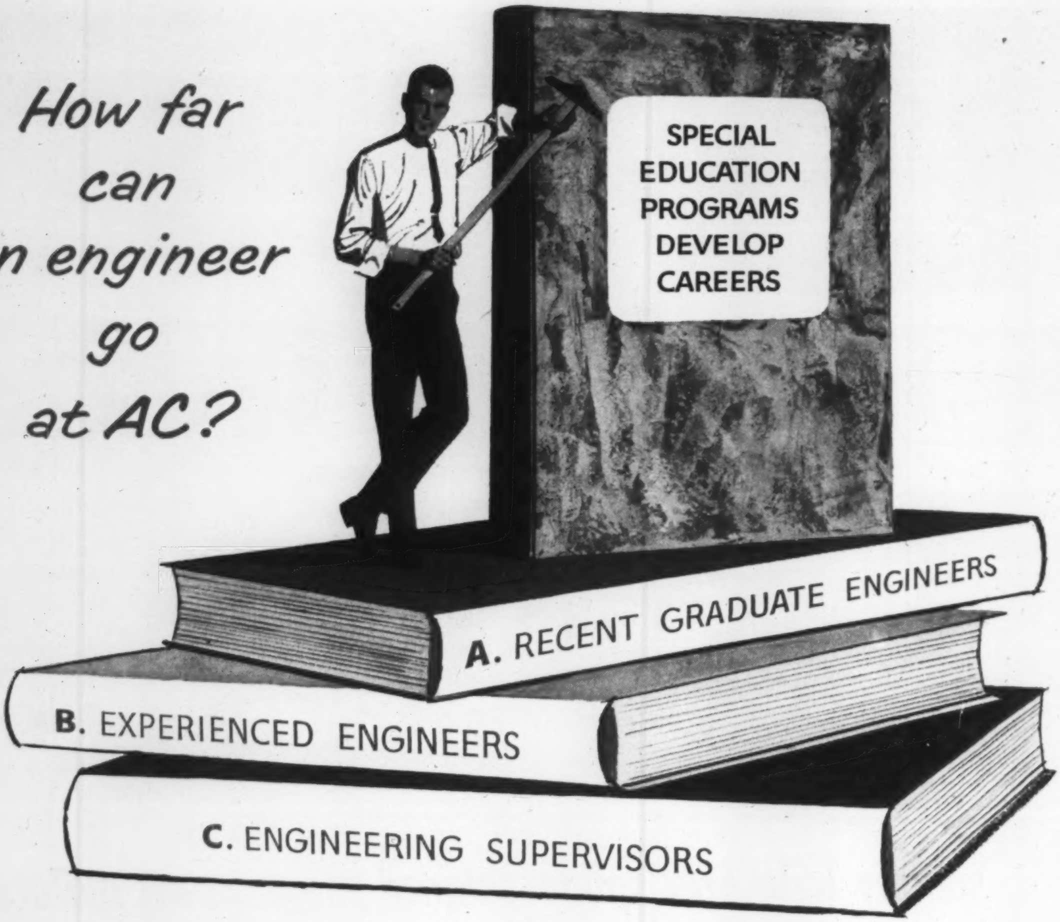

Finest "in house" programs anywhere

When you work in AC's instrumentation business, AC offers free comprehensive training programs that will help you grow professionally and enhance your status. Just look at these opportunities . . .

Program A—for recent graduate engineers—gives you a solid foundation in the theory and application of inertial guidance systems and servomechanisms. You attend classes three hours per day for four months, all on company time.

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These thoroughly practical courses—taught by university professors or recognized AC specialists—constitute AC educational "extras." AC offers them in addition to their educational assistance programs for men who wish to study for degrees in nearby universities.

You may be eligible for training

If you are a graduate engineer in the electronics, electrical or mechanical fields, or if you have an advanced degree in mathematics or physics, you may be able to participate in these programs while you work on AC's famous AChiever inertial guidance system or a wide variety of other electromechanical, optical and infra-red devices.

For more details, just write the Director of Scientific and Professional Employment: Mr. Robert Allen, Oak Creek Plant, Dept. C, Box 746, South Milwaukee, Wisconsin.

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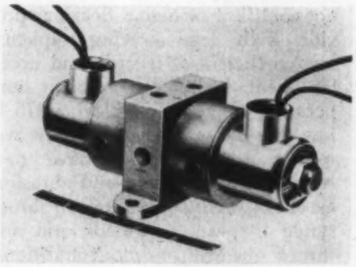
AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS



or tapped for standard connection (1/8 or 1/4 NPT). **Airmatic Valve Inc.**, 7317 Associate Ave., Cleveland 9, Ohio. G

Circle 719 on Page 19

Thermocouple Wires

withstand 2000-F ambient temperatures

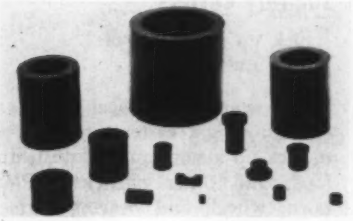
For use where high temperatures must be measured accurately and where thermocouple leads must pass through zones of extreme heat, metal-sheathed thermocouple wires are available. Units are manufactured in long lengths with conductors of either Chromel-Alumel or Iron-Constantan. Insulation is crystalline magnesium oxide compacted to maximum density inside sheath. Inconel sheaths are completely impervious to moisture, oils, petroleums, ozone, and solvents, and are immune to age deterioration. Twelve standard constructions, with wire gage sizes from 15 to 28, can be furnished from stock. Special constructions are also available. **Revere Corp. of America**, Wallingford 2, Conn. B

Circle 720 on Page 19

Oilless Bearings

for temperatures from −250 to +375 F

Bearings of Arguto-MP, an alloy of plastics, can be molded to any shape, and are machined to close tolerances. Bearing material will



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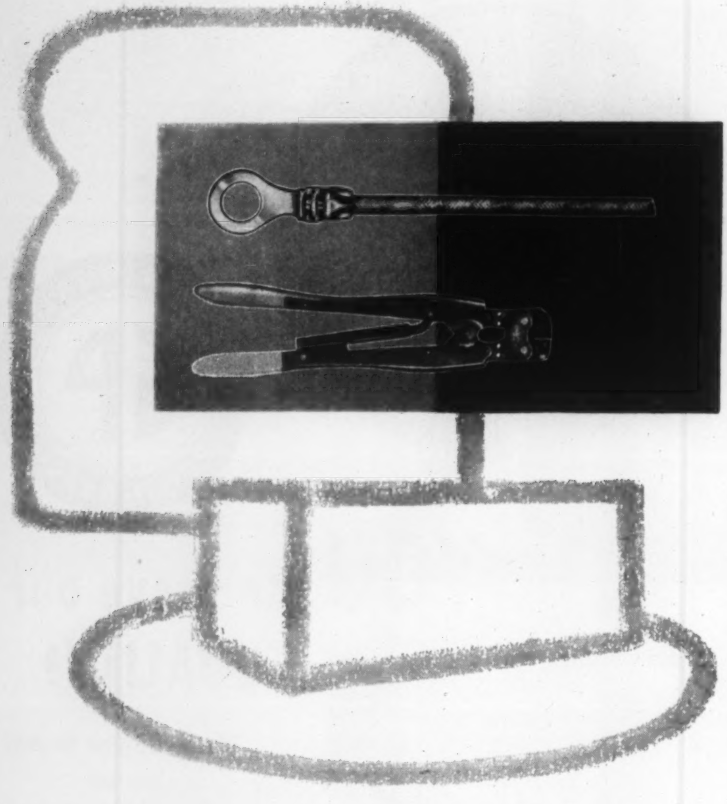
Circle 556 on Page 19



A basic "bread and butter" team

Each A-MP terminal line and matching tool were designed to go together like bread and butter . . . and to be as basic to your electrical circuit termination program.

Reliability and lowest cost also go together like bread and butter in this A-MP tool and terminal method. There are no hidden "caviar" costs or doubtful connections. In fact, total installed cost is lower than any other terminal-attachment method, while the entire termination operation is mechanically quality-controlled to create the highest reliability in the finished product.

In addition, AMP manufactures a more diversified line of termination products than any other firm in the world, ranging from top quality circuit terminals and splices to versatile multi-circuit units for the most complex electronic components.

Here, truly, is a line that will earn its bread and butter in your plant day after day, year after year.

Write for more information on this modern, low cost circuit termination method.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

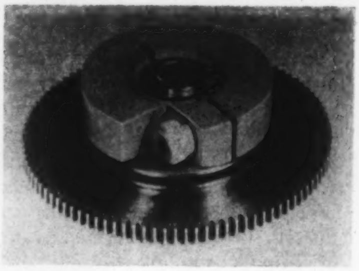
Circle 557 on Page 19

not cold-flow or melt. Bearings provide high load-carrying capacity, low coefficient of friction and excellent heat dissipation, ambient temperature range of −250 to +375 F, low thermal expansion and low water absorption. They have good resistance to corrosion and abrasion, excellent wear properties in broad range of speeds and loads, and continued operation without additional lubrication. **Arguto Oilless Bearing Co.**, 149 W. Berkley, Philadelphia, Pa. E

Circle 721 on Page 19

Slip-Clutch Gear

miniature unit absorbs shock of sudden stops



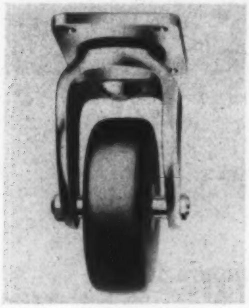
Only 5/16 in. long, miniature slip-clutch gear is entirely self-contained and can be clamped to any 0.125 or 0.12-in. diam shaft. It absorbs shock of sudden stops in servo and instrument mechanisms, prevents overload damage to gear teeth, bearings, and components. Standard gears are 96 pitch, AGMA Precision 1, and range in size from 66 to 110 teeth. Gear is preset to slip at any desired torque between 1 and 15 oz-in. Construction meets MIL-E-5400 requirements. Gear is lubricated sintered bronze, body and spring are corrosion-resistant steel, and clamp is anodized aluminum. **Precision Mechanisms Corp.**, 577 Newbridge Ave., East Meadow, N. Y. D

Circle 722 on Page 19

Sanitary Casters

pick up minimum of dust and dirt

B-Line 4 and 5 in. wheel swivel and matching rigid casters are designed to pick up a minimum of dust, dirt, food, and other particles. Plate, horn, wheel, and bearing surfaces



are smooth, with no cracks or recesses to hold dirt. Minimum of $\frac{1}{2}$ in. is provided between wheel and horn to permit cleaning. Heat-treated, high-strength, aluminum-alloy construction will not rust in steam or hot-water cleaning. Wheel and swivel bearings are sealed to prevent dripping grease, and nonmarking wheel tapers inward at base for easy cleaning. Load capacities are 400 lb per caster for 4-in. wheel swivel and rigid casters and 450 lb per caster for the 5-in. units. **Bassick Co.,** Fairfield Avenue, Bridgeport 5, Conn. B

Circle 723 on Page 19

Stainless-Steel Stock

threaded material is
12 to 24 in. long

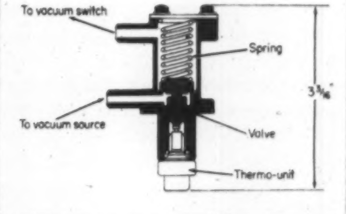
Type A9 stainless-steel threaded stock is available in No. 6 size to $\frac{3}{8}$ in. diam, with from 32 to 16 threads per in. It is furnished in 12 to 24-in. lengths. **PIC Design Corp.,** 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

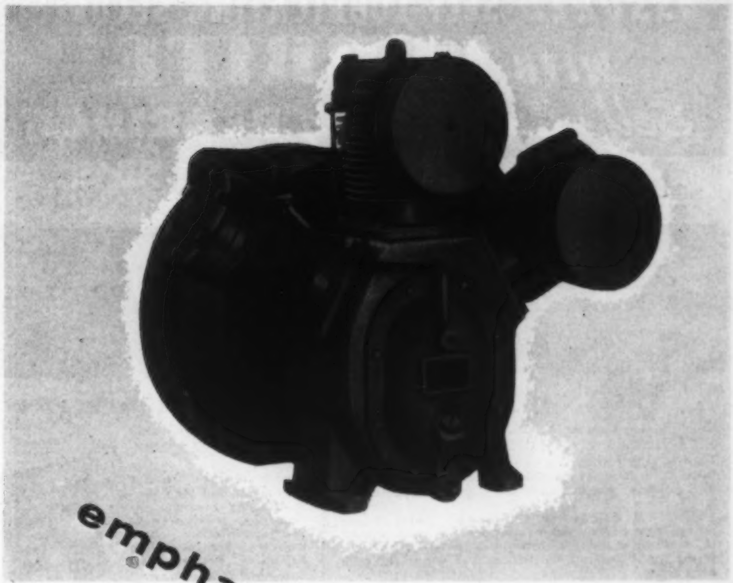
Circle 724 on Page 19

Actuating Valve

is temperature controlled

Actuating valve controls application of vacuum or pressure according to any predetermined temperature range of a fluid. It consists of a heat motor actuating a spring-loaded





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product quality

with IR air compressors*

Ingersoll-Rand Compressors bring new efficiency to air-operated equipment through modern design and exclusive features. Engineered for trouble-free service and maximum performance, Ingersoll-Rand Air Compressors can be supplied bare, base-plate mounted or receiver mounted.

To assure dependable performance in the equipment you manufacture you'll want to specify an air compressor that's known and recognized as the best. The people you're going to sell *know* that Ingersoll-Rand Air Compressors set the standard for dependable, low-cost operation.

Ingersoll-Rand
11 Broadway, New York 4, N.Y.

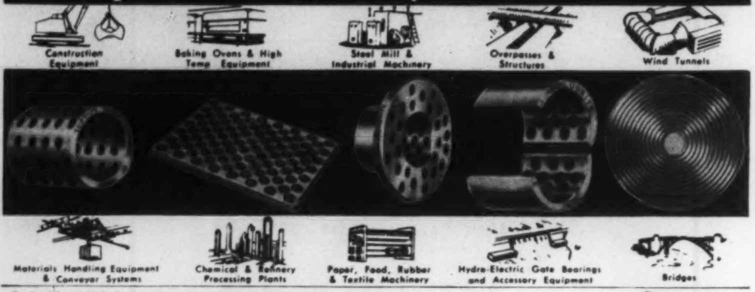
* air-cooled compressors
½ through 20 horsepower

Other compressors to 6000 horsepower

3-676

Circle 558 on Page 19

ASSURED SELF-LUBRICATING SECURITY
WITH LUBRITE®
Self-Lubricating BEARINGS


Construction Equipment
Baking Ovens & High Temp Equipment
Steel Mill & Industrial Machinery
Overpasses & Structures
Wind Tunnels
Materials Handling Equipment & Conveyor Systems
Chemical & Refinery Processing Plants
Paper, Food, Rubber & Textile Machinery
Hydro-Electric Gate Bearings and Accessory Equipment
Bridges

Lubrite self-lubricating bearings offer great versatility in hundreds of fields where dependability and superior performance are of prime importance.

Lubrite Bearings, with clean, permanent, maintenance-free self-lubrication are designed to withstand severe loadings, temperature extremes, submersion, corrosion and other adverse conditions.

Lubrite may be just the bearing you need in your designs to obtain better results.

Consult our Engineering Department on your application. No obligation.

Send for this free 20-page Lubrite Manual No. 55—it contains complete information, technical data and specifications about Lubrite Self-Lubricating Expansion Plates and Bushings. Write today!

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MERRIMAN BROS., INC.
187 AMORY STREET, BOSTON 30, MASSACHUSETTS
Circle 559 on Page 19

TIME
Is the only basis for
PLANNED
maintenance

Hobbs INDUSTRIAL HOUR METER

TOTAL HOURS

1 Encourages on-time performance of planned maintenance — for superior performance and maximum utilization of your products.

2 Sets up a sound basis for rental and leased equipment.

3 Indicates operating time in hours and minutes — at a glance.

4 A true timing instrument — not a revolution counter.

Distributors in Principal Cities
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FOR ALTERNATING AND DIRECT CURRENT

Hobbs a-c Hour Meter has a wide range of applications; available in 120, 240 and 480 v; 50 or 60 cps. Hobbs d-c Hour Meter indicates running time of internal combustion engines; available in 6, 12, 24, 32, 64 and 110 v.

Symbol of SW Excellence

John W. Hobbs Corporation
A DIVISION OF STEWART-WARNER CORPORATION
2062 YALE BLVD., SPRINGFIELD, ILLINOIS

Circle 560 on Page 19

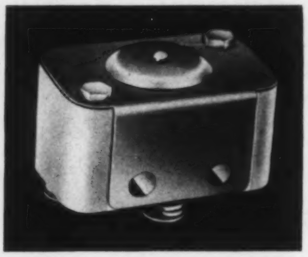
valve. Valve, designed specifically for use in carburetion systems, has other industrial applications. It is available in various temperature range calibrations to control flow at various pressures. **Rochester Products Div., General Motors Corp.,** Rochester 3, N. Y. N

Circle 725 on Page 19

Miniature Switch

for use in temperatures to 800 F

SPDT limit or sensitive switch, Klixon 21135-1, maintains operating characteristics during long exposure to temperatures up to 800 F. Switch is designed for precision applications on aircraft and guided missiles, and for use in furnaces, ovens, and other high-temperature environments. All components are completely inorganic. Switch resists 20 g vibration in frequencies of 25 to 2000 cps. Capacity is 5 amp, 30 v dc, resistive. **Metals & Controls Div., Texas Instruments Inc.,** Attleboro, Mass. B



Circle 726 on Page 19

Preassembled Fastener

combines spring washer and hex nut

Tenz-Nut combines effectiveness of a spring washer with standard hex nut in a single unit which can be hopper fed on automated assembly systems. Reactive spring pressure is achieved by use of a cupped-type washer. Spring washer is free to turn, yet is firmly attached to nut and will not come off. Nut is easy to start, since it is flared on washer end. Washer, which exerts tension over large reactive range, keeps bolted assemblies tighter longer by compensating for normal thread wear and bolt elongation. Cupped-type washer does not mar surface to

DELROYD

WORM GEAR SETS

New high efficiency... higher horsepower ratings

JUST OUT

Send for this new Delroyd Worm Gear Sets Catalog #3800. It contains comprehensive information on selection of worm gears, calculation of bearing loads, and other data, much of which has never been published before.

HOW TO CALCULATE BEARING LOADS
PRINCIPAL FORCES AND BEARING LOADS IN A WORM AND GEAR SET
BEARING LOADS
WORM and GEAR DATA
WORMS
GEARS

DE LAVAL *Steam Turbine Company*

858 Nottingham Way, Trenton 2, New Jersey

DL-459

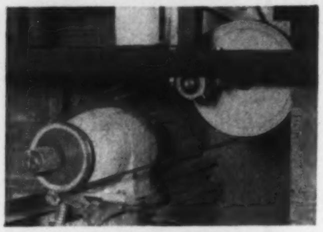
When the job calls for variable speed . . .

✓ You supply the problem—

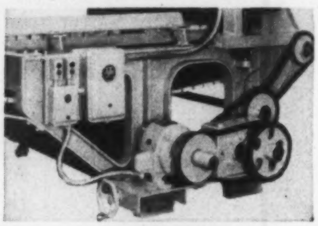
✓ Lovejoy will furnish the solution

✓ . . . saving you time and money in the bargain

TYPICAL EXAMPLES:

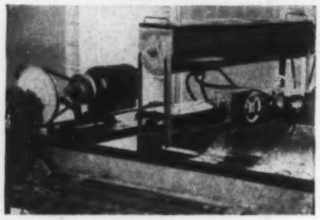


Type 160 Pulley and No. 200 Tilting Motor Base proved the right combination for a mailing machine.



Proper drive for a slat bed rip saw is provided by a Type 302 Pulley.

Type 135 Pulley meets all requirements on a vibrating machine.



This Lovejoy "double" solved a grading machine problem—Type 145 Pulley and No. 2 Select-O-Speed.

Here's how . . .

❶ Lovejoy sends you full information on the types of variable speed pulleys and transmissions available . . . along with a guide sheet to help you supply us with pertinent information on the type you need and the service you require.

❷ Depending on your requirements, Lovejoy rushes recommendations, blue prints, suggested solutions to problems . . . or, if you desire, will send a representative to give you first-hand assistance. For standard or relatively simple applications, cost quotations can be furnished immediately.

- Speed ratios: up to 10 to 1
- Horsepowers: fractional to 15
- Constant belt alignment
- Instant speed changes while equipment is running
- Easily installed on new or old equipment.

Put Lovejoy's exclusive individualized service to work for you: a complete line of variable speed pulleys and transmissions *plus* personalized engineering guidance to assure full satisfaction. Send for Catalog P58 and Form 118F today.

LOVEJOY FLEXIBLE COUPLING CO.

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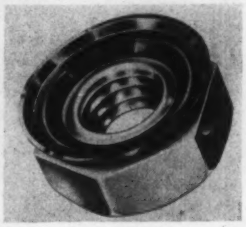
Circle 561 on Page 19



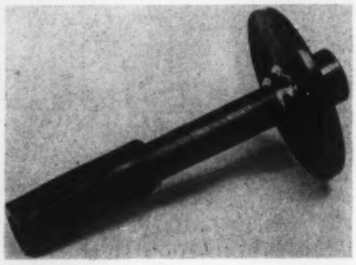
which it is applied, making it useful for assembly of polished or plated parts. It can also be filled with mastic and used as a sealing washer where liquid-tight assembly is required. **Reliance Div., Eaton Mfg. Co.,** S. Erie & Charles Streets, Massillon, Ohio. G

Circle 727 on Page 19

Flexible Shaft Coupling

eliminates close alignment of parts

Consisting of tightly wound flexible shaft core made of music wire with terminals on each end, flexible shaft coupling eliminates close alignment of parts and allows movement of either end of coupling while rotating. It is available with terminals to suit any requirement and with flexible shaft core in sizes of 3/16, ¼, 5/16, ⅜, 1, and 1¼ in. **Stow Mfg. Co.,** 11 Shear St., Binghamton, N. Y. N



Circle 728 on Page 19

Ten-Turn Potentiometer

in ranges from 25 to 120,000 ohms

Low-cost, ⅞-in., ten-turn precision wirewound potentiometer operates over a temperature range of −55 to +105 C. Designated Model 510, it is available in ranges from 25 to 120,000 ohms. Standard linearity tolerance is ±0.25 per cent with tolerances of ±0.1 per cent on special order. Up to 46 additional

Automotive Power Steering Manufacturer Specifies

OSTUCO
Mechanical Seamless Tubing
FOR
SURFACE FINISH

Cold drawing Ostuco tubing through precision ring die on cold draw bench at Shelby mill. Mandrel controls and sizes I.D.

“ Automotive components are our business. We have produced literally millions. And we're still learning every day.

"One of the lessons we learned early in the game is that you can't beat Ostuco tubing for surface finish. It cuts our machining costs, keeps us on top competitively.

"There are other reasons, too, why Ostuco tubing tops our preferred list. We like its consistently close tolerances and unvarying quality, shipment after shipment. You might say we like its *product integrity* . . . ”

To learn more about what Ostuco tubing can do for *your* production, contact your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.* AA-9431

OSTUCO SHELBY OHIO OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

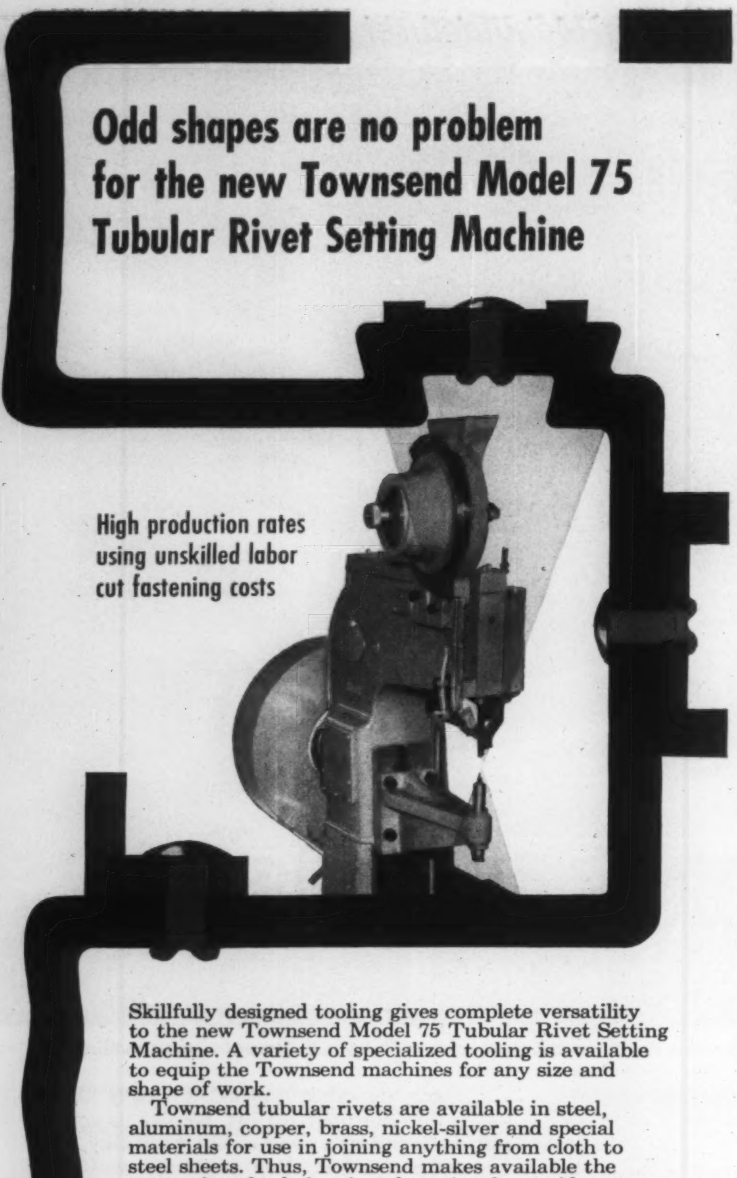
of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

Circle 562 on Page 19

Odd shapes are no problem for the new Townsend Model 75 Tubular Rivet Setting Machine



Skillfully designed tooling gives complete versatility to the new Townsend Model 75 Tubular Rivet Setting Machine. A variety of specialized tooling is available to equip the Townsend machines for any size and shape of work.

Townsend tubular rivets are available in steel, aluminum, copper, brass, nickel-silver and special materials for use in joining anything from cloth to steel sheets. Thus, Townsend makes available the economies of tubular rivet fastening for a wide range of products in a number of different materials. Townsend's experienced fastening engineers provide application design service.

If you wish to enjoy the economies of fastening with tubular rivets, write for complete information on the versatile Model 75 Setting Machine and the complete line of Townsend tubular rivets. Townsend Company, P. O. Box 237-E, New Brighton, Pa.

[illegible]

Townsend
COMPANY • ESTABLISHED 1816

[illegible]

Sales Offices in Principal Cities

[illegible]

In Canada: *Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario*

Circle 563 on Page 19

terminals can be added to standard unit for special applications. Sleeve bearings at both shaft ends are standard, and shaft diameter is $1/4$ in. Unit is available from stock in seven values from 1000 to 100,000 ohms. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 729 on Page 19

Constant-Level Oiler

incorporates oil-level sight

Style CS oiler automatically maintains oil in a bearing at a constant level. It incorporates a sight in base of oiler, offering visual check of oil level. Unit is furnished with $1/2$-in. pipe thread on side and bottom outlet. It can be filled conveniently through top filler cap. Large air intake of $1/8$-in. female pipe thread permits insertion of an air filter. **Oil-Rite Corp.**, 2376 Waldo Blvd., Manitowoc, Wis. K

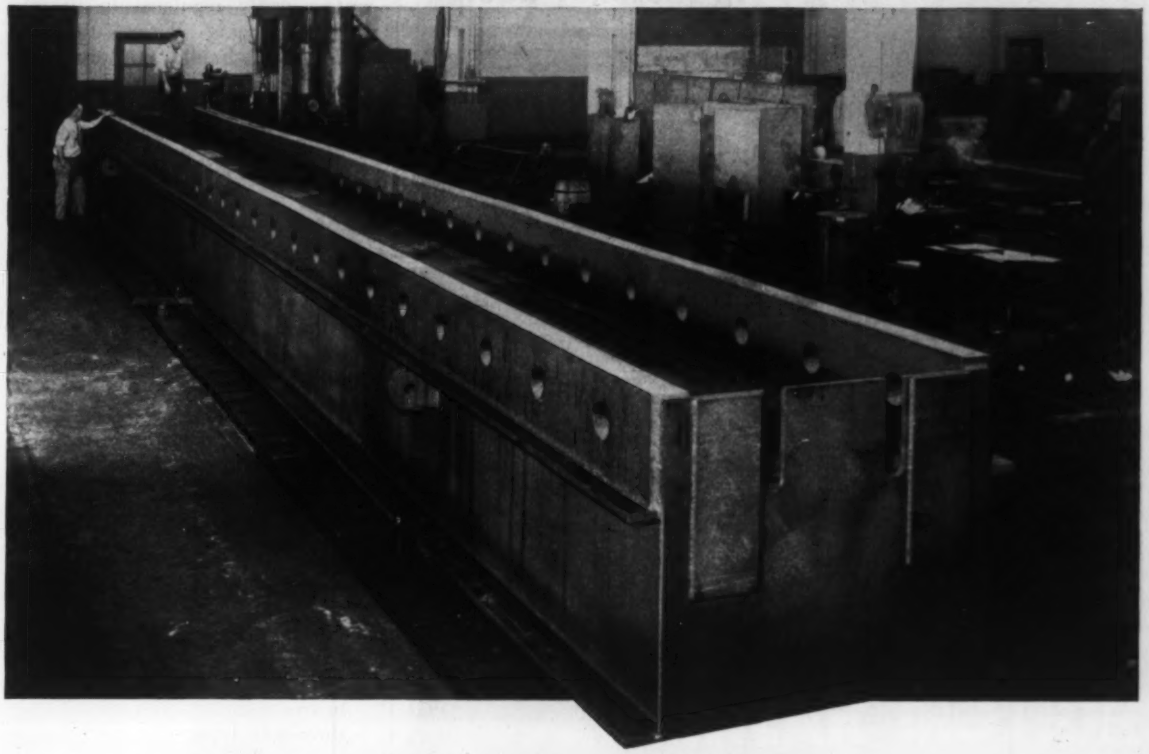
Circle 730 on Page 19

Rotary Torque Unit

permits 5 to 360-deg precision shaft rotation

Self-contained, hydraulic rotary-torque power unit, incorporating a variety of built-in controls, provides possibilities for low-cost, controlled hydraulic power in many machine-tool, aircraft, missile, and commercial applications. Operating at a power input range from 50 to

STEEL-WELD FABRICATION . . .



PRECISION WELDMENTS

Fabricated and Machined to Specification!

The 54-Ton Weldment above, which is 58′-8″ long, is the base of a Stretcher-Leveler Machine for use in the production of aluminum sheets. This unusual weldment is one of thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment.

When your design calls for weldments of any kind, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon Company you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

See Sweet's Product Design File for information on Facilities, or have a Mahon sales engineer call at your convenience.

Use WELDED STEEL for
100% Predictability
and Greater Strength
with Reduced Weight!

THE R. C. MAHON COMPANY • Detroit 34, Michigan
SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

MAHON

Circle 564 on Page 19

plenty of cost-cutting possibilities in fastener design

BEFORE...
Separate Bolts, Nuts and Washers complicate inventories, increase assembly costs.

AFTER...
Washers as integral parts of bolts and nuts eliminate problems, speed assembly at lower cost.

BEFORE...
Appliance manufacturer installed leg leveling bolt; used square head fastener in crating.

AFTER...
Circle B leg leveling bolt designed with Phillips head, at no extra cost, now does both jobs.

IN THESE TWO CASES, savings were realized in every step of the operation from lower first cost of the fasteners through inventory to final assembly.

Important Savings often overlooked

Fasteners usually represent a small part of the total cost of assembly. However, this doesn't mean you can't save money on them. Actually, here is where cost reductions often can be made most readily.

By being familiar with a comparatively few basic principles affecting costs of headed parts, you can specify and buy them at most economical cost. With the assistance of specialized advice from an experienced company like Buffalo Bolt, you can often effect further savings.

As a guide in designing and buying headed parts, we have incorporated the important principles into a handy booklet complete with drawings and charts. From our field offices and plants, we can supply you with practical technical assistance, quotes and deliveries.

For a copy of the booklet, write our main plant at North Tonawanda. For immediate service, technical information or quotations, contact the office most convenient for you.

How to Specify
FASTENERS
and Save

BUFFALO BOLT COMPANY
Division of Buffalo-Eclipse Corporation
North Tonawanda, N.Y. • Princeton, Illinois
MAKING BOTH FASTENERS AND FRIENDS FOR 100 YEARS

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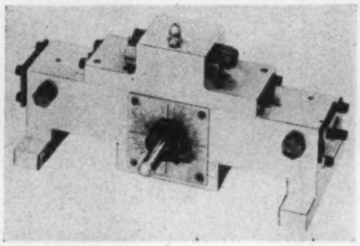
WESTERN OFFICE Chicago HArrison 7-2178
EASTERN OFFICE New York City REctor 2-1888
CENTRAL OFFICE North Tonawanda JAckson 2400 (Buffalo)

Circle 565 on Page 19

1000 psi, unit converts hydraulic pressure into reciprocating rotary motion easily regulated to fit all job requirements. Power output at 1000 psi hydraulic pressure will provide 500 lb-in. of working torque over range of rotation from 5 to 360 deg. Unit will self-reciprocate within its adjusted range of motion, as well as in semimanual or full manual operation. All valving and speed controls are built into the unit. **Industrial Sales Div., Cleveland Pneumatic Industries Inc.,** 64 Old Orchard, Skokie, Ill. J

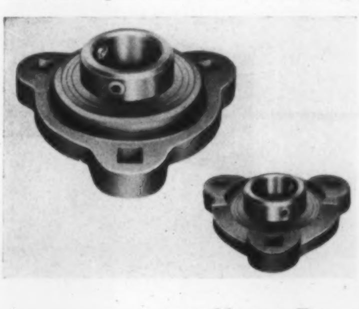


Circle 731 on Page 19

Flanged Bearing Units

in two and
three-bolt types

Two new bearing types have been added to L-Series ball-bearing units. LF three-bolt (shown) and LFT two-bolt flange bearing units are available in ten standard sizes from ¾ to 1 7/16 in. L bearing cartridge with spherical OD is permanently mounted in one-piece malleable housing which provides maximum strength with light weight. Design of housing permits either flush or recessed mountings for maximum application flexibility and desired shaft extension with minimum overhang. Housing also provides full housing contact under bearing ball path. Precision self-alignment takes place automatically between spherical OD of bearing



and spherical ID of housing. Units are prelubricated for long life and are completely assembled. **Sealmaster Bearing Div., Stephens-Adamson Mfg. Co.,** Ridgeway Avenue, Aurora, Ill. I

Circle 732 on Page 19

Speed Reducers

are fin and fan-cooled types

External cooling fins plus powered cooling fan provide 80 per cent more capacity in Hi-Line reducers than in comparable nonventilated reducers. Units use heavy-duty worm and gear reduction, and also feature heavy-capacity bearings, shorter center distance between worm and gear, and improved heat-dissipation characteristics. Model S, shown, is a horizontal, right-angle unit available with output shaft above or below center. Sizes range from 1.33 to 5.25 in. center distance. **Ohio Gear Co.,** 1333 E. 179th St., Cleveland 10, Ohio. F

Circle 733 on Page 19

Revolution Counter

seven-digit unit is weatherproof

Weatherproof sealing is featured in a small, nonreset, add-subtract revolution counter. The seven-digit unit is totally enclosed in die-cast case with window. It is available sealed for outdoor use or unsealed. It can be furnished with adapter for flexible-shaft drive where flexibility in positioning counter is required. Unit adds ten counts for forward shaft revolution and subtracts same number for reverse revolution. It has speeds to 10,000 cpm. Counter is available with top-coming or top-going shaft revolution,

Circle 566 on Page 19→

NOW! Adjustable Diameter and Open THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your LINEAR MOTIONS

Precision Series "A" and Low Cost Series "B" BALL BUSHING

Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION · ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of 1/8" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

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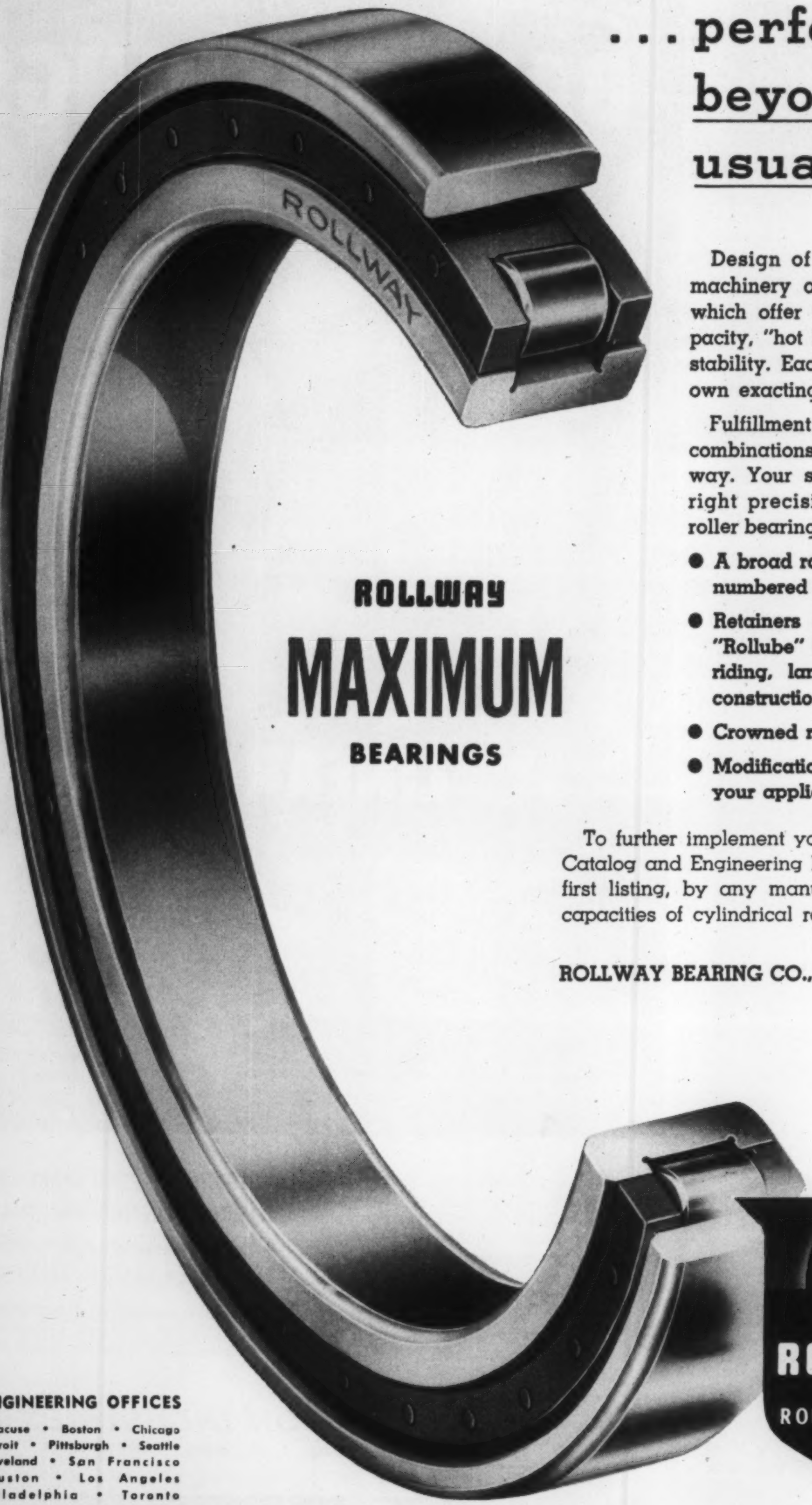
Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting



. . . performance beyond the usual . . .

ROLLWAY

MAXIMUM

BEARINGS

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
- **Retainers of standard bronze or "Rollube" ferrous alloy, in roller-riding, land-riding, or broached construction**
- **Crowned rollers**
- **Modification of any factor to meet your application**

To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

ROLLWAY BEARING CO., Inc., Syracuse 1, N. Y.

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Syracuse • Boston • Chicago
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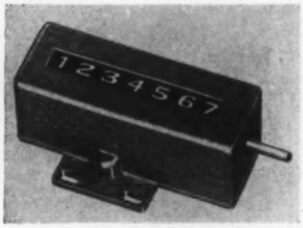
ROLLWAY
Maximum
ROLLER BEARINGS

Circle 567 on Page 19



and with right or left shank extension. **PIC Automation Controls Div., General Controls Co.,** 8062F McCormick Blvd., Skokie, Ill. J

Circle 734 on Page 19

Manual Control Valves

in ¾ through 6-in. sizes

Handwheel-operated control valves, designated Series LM, feature single-seated valve body with thick walls cast to 600 lb ASA rating. Valves are available in ductile iron, steel, bronze, and many high alloys. They are suitable for use with hard-to-handle process fluids. Special seat materials, such as Teflon, provide tight shut-off. Complete range of sizes, from ¾ through 6 in., with separable or integral flanges, is available. Split valve body allows quick disassembly for inspection and maintenance. **Conoflow Corp.,** Dept. D-7, 2100 Arch St., Philadelphia 3, Pa. E

Circle 735 on Page 19

One-Piece Fastener

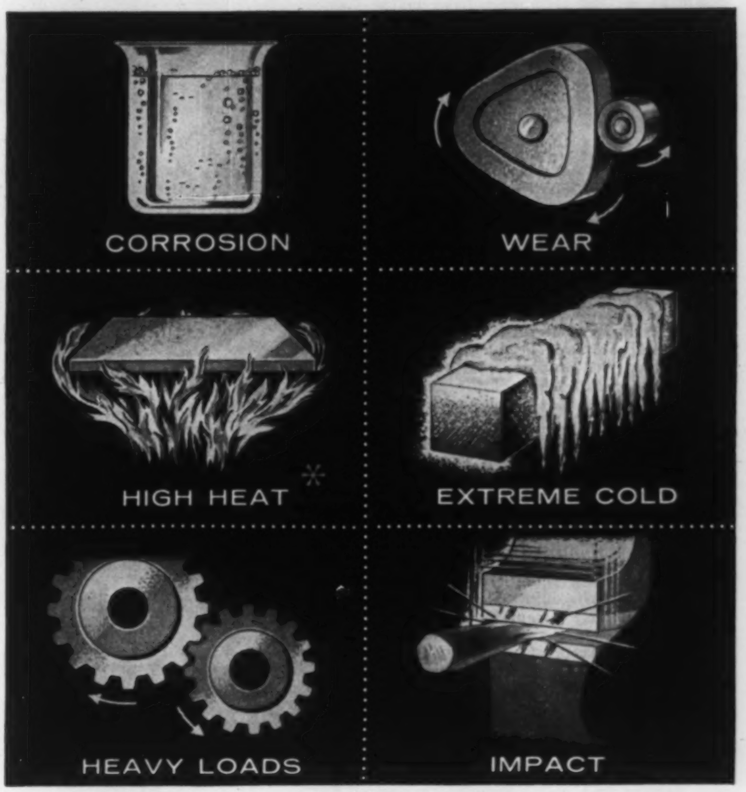
clips printed-circuit boards to chassis

Spring-steel, one-piece Speed Clip serves as a spacer and to fasten printed-circuit boards to chassis in electronic equipment. Unit is self-retained in fastening position for fast, easy assembly. Bowed spring legs snap into place and lock on

AMPCo ®

Do you have to

COPE WITH THESE CONDITIONS?



**High heat as compared to other copper-base alloys.*

you combat them all with an

AMPCO® METAL

What does a copper-base alloy have to do for you? Whatever it is, there's a grade of Ampco Metal — or other Ampco alloy — that does the job exactly.

Equally important, you can select the best, most economical form of production — sand casting, centrifugal casting, shell mold, precision casting, forging, fabrication, extrusion, sheet, plate.

Call in your Ampco field engineer. Write for bulletin.

G-30

AMPCO METAL, INC., Dept. 30F, Milwaukee 46, Wis.
WEST COAST PLANT: BURBANK, CALIFORNIA • SOUTHWEST PLANT: GARLAND (DALLAS COUNTY), TEXAS

Circle 568 on Page 19

QUALITY BALLPOINT PEN DEPENDS ON UNIFORMITY OF 8 GRC "MATED" PARTS

Die Cast and Molded Components Assure Trouble-free Operation of Esterbrook's New Rotating Mechanism

GRC mass-production techniques have again provided a new dimension to designers faced with a difficult situation. Esterbrook engineers, realizing that most people pick up a pen repeatedly the same way, evolved a rotating mechanism to avoid wearing the ballpoint unevenly and to achieve better ink distribution. The intricate mechanism, however, presented a production problem. Parts had to be uniform, durable, meet close tolerances in order to assure proper mating of components and dependable functioning of the assembled pen.

GRC's exclusive patented methods for the precise automatic production of tiny parts solved the problem, and at lower costs. Gries molded five of the parts in duPont nylon, die cast two others in zinc alloy for strength and greatest economy. The eighth was Gries nylon counterpart for an originally-scheduled screw machine part, produced for a fraction of the cost and more satisfactorily. These eight parts form the foundation of the mechanism for this new-type pen.

Uniformly accurate, clean, well within critical tolerances, these GRC die cast and molded parts eliminated the necessity of selective assembly and insure trouble-free operation by fitting mating parts exactly. Tests of the pen showed parts worked like new after the equivalent of more than a year's normal use, still worked smoothly after the equivalent of five year's hard use. (See illustration at left above.)

This high quality pen is typical of the new designs and cost saving economies possible through Gries' unique single cavity molding techniques and ingenious die casting methods. To find out how GRC can help you, write for their bulletins on tiny zinc alloy die castings and injection molded small plastic parts, or send prints for immediate quotations. There is no minimum size. Maximums are 1¾" long, ½ oz. in zinc alloy; 1¼" long, .03 oz. in plastic.

ESTERBROOK

GRC
GRC
zinc
die
castings

WRITE TODAY FOR BULLETINS

WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

GRIES

GRIES REPRODUCER CORP.
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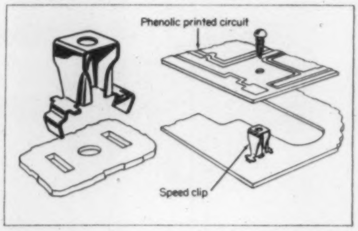
Circle 569 on Page 19



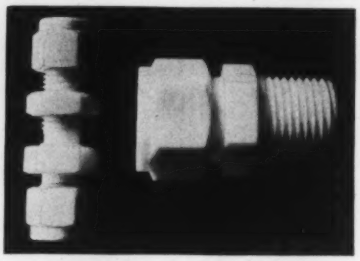
underside of chassis. Once clips are in place, circuit board is positioned and screws are inserted, passing through board and between spring leg of clip into chassis. Clip provides better than ½ in. clearance between circuit board and chassis. It has a broad, flat head which provides substantial base at each fastening point to prevent cracking brittle circuit boards due to overtorquing of screws. **Tinnerman Products Inc.**, P. O. Box 6688, Cleveland, Ohio. F

Circle 736 on Page 19

Tube Fittings

are now available in Teflon

Swagelok tube fittings are available in all standard shapes and sizes in Teflon, for tubing from 1/16 to 1 in. OD. Special sizes and shapes are available on order. **Crawford Fitting Co.**, 884 E. 140th St., Cleveland 10, Ohio. G



Circle 737 on Page 19

Machine Tool Switch

operates continuously for 45 million cycles

Small, heavy-duty limit switch is designed with all major friction points of either nylon or oil-impregnated bearings. Nylon-to-nylon heavy-duty latch mechanism withstands 45 million actuations. Loxswitch Model M has full 600-v industrial rating. Extra wide ⅜-in. contact gaps eliminate possibility of contact welding. Actuating torque

of only 45 oz-in. trips switch. Unit is water, oil, and dust-tight, NEMA 12. Three different bases and five lever styles are available. **R. B. Denison Mfg. Co.**, 102 St. Clair Ave. N.W., Cleveland 13, Ohio. F

Circle 738 on Page 19

Polyurethane Foam Tape

has pressure-sensitive adhesive backing

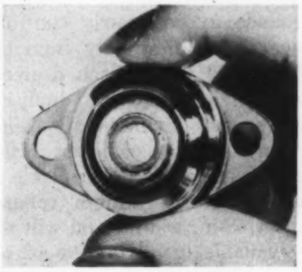
Inexpensive polyurethane foam tape is coated with high-temperature pressure-sensitive adhesive. Adhesive holds in place permanently, despite temperature fluctuations from 0 to 300 F. Both polyurethane and adhesive are noncorroding and impervious to moisture. Tape has excellent sound and heat-insulating qualities, superior cushioning against shock and vibration, is an effective seal against dust and dirt, and is chemically inert. Foam, which is flexible, maintains vibration and shock-absorbing life indefinitely. Tapes in a wide range of widths and thicknesses are available. **Richards, Parents and Murray Inc.**, 312 Seventh Ave., New York 1, N. Y. D

Circle 739 on Page 19

Miniature Flange Bearing

is self-aligning and self-lubricating

Miniature two-bolt flange bearing for use in home appliances and other light machinery is available for shaft sizes 1/4, 5/16, 3/8, and



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to your exact requirements

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EXTRUDED
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DIE CUT
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PRECISION GROUND

Channels or chicken pluckers . . . washers or weatherstrips . . . you name it and we'll make it! And we'll produce it to meet your most precise design specifications! Stalwart offers you a complete rubber parts *service* . . . Rubber Engineers develop your special compound from natural, synthetic or silicone rubbers . . . Laboratory Technicians pre-test actual performance . . . our own completely equipped Tooling Department produces the necessary extrusion dies . . . skilled Production Personnel operate the latest rubber machinery for maximum economy, dependable delivery . . . and *our* Quality Control Department protects *your* interests! This means you get higher quality at a lower cost . . . the result of nearly 40 years of fabricating experience! To solve tough rubber parts problems . . . cut assembly costs, *specify Stalwart.*

Write today for complete information.
Ask for your copy of Stalwart Catalog SR-59.

STALWART
RUBBER COMPANY

180 Northfield Road • Bedford, Ohio
Manufacturing facilities in
Jasper, Georgia and Bedford, Ohio

Circle 570 on Page 19

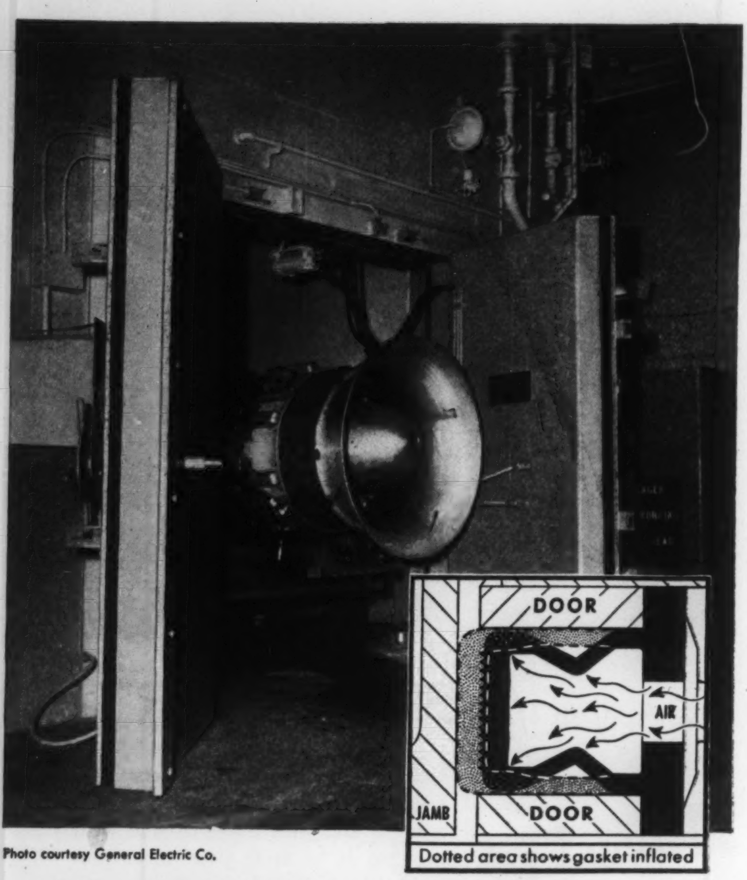


Photo courtesy General Electric Co.

Dotted area shows gasket inflated

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners*. Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle *or* as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

Circle 571 on Page 19

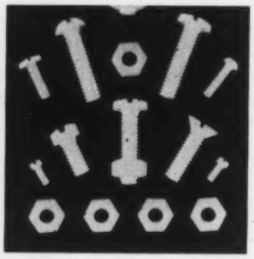
7/16 in. Housing is 20-gage steel, with corrosion-resistant cadmium plating. Sintered bronze bushing is permanently self-lubricating. Lubricant automatically reaches bearing surface by capillary action through porous bushing walls. Two-bolt design eliminates need for extra bolts or mounting holes, and permits vertical or horizontal mounting. Spherical contact between ball and liner assures constant self-alignment without side play. **Randall Graphite Bearings Inc.**, Greenlawn & Lake Avenues, Lima, Ohio. G

Circle 740 on Page 19

Nylon Screws

in sizes from No. 4-40 to ¼-20

Molded nylon machine screws are lightweight, corrosion resistant, and have low dielectric properties. Molded to close tolerance with clean threads, they are available in binding, round, fillister, flat, and washer commercial head types. Phillips or slotted heads are furnished. Sizes range from No. 4-40 to ¼-20 in all standard lengths to 1 in. **Richco Plastic Co.**, 4445 W. Fullerton Ave., Chicago 39, Ill. I



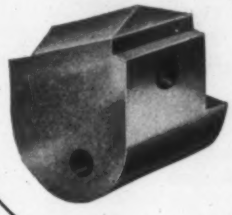
Circle 741 on Page 19

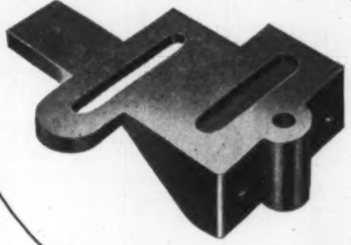
Flexible Polyethers

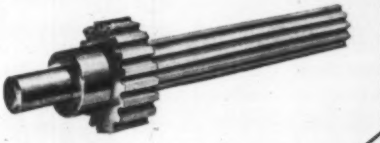
have controlled range of flexibility

Completely odorless from the time of manufacture, flexible foams can be made in an exactly controlled range of compressibility from very soft to very firm. Each degree of compressibility can be duplicated exactly and maintained precisely for any size lot of foam. High-Cushion Nopcofoam is available immediately with medium compression in 48-in. widths, and will soon be available in all degrees of soft-

V-R Carbides...







for your TOUGH design problems!

Extremely high rigidity under a given load . . . low coefficient of expansion for greater dimensional stability . . . less deflection . . . high surface finish obtainable (less than one micron) . . . low magnetic properties . . . high density . . . stability at extremely high temperatures . . . greater resistance to wear and corrosion. These are the outstanding characteristics which have made V-R carbides far superior to all other metals for many design applications.

Designers know that V-R can supply carbides with any combination of these characteristics to meet almost any problem situation. Just tell us which characteristics you need and we will design a carbide grade to exactly fill your requirements.

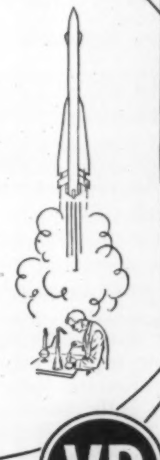
Put the exceptional properties of these unusual metals to work solving your tough design problems. Contact your nearest V-R representative or send us the details of your particular application.

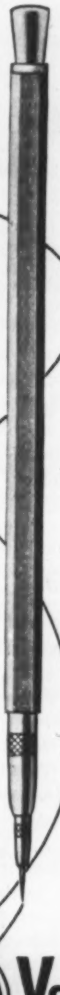
Metals of tomorrow ... TODAY!

Vascoloy-Ramet Corporation is a pioneer manufacturer of refractory metals . . . making its substantial contribution to America's growth by developing special metals with exceptional characteristics to meet the changing needs of industry.

29 years of V-R research, engineering and manufacturing experience . . . covering thousands of application problems . . . have produced the technical know-how built into all V-R products.

This same know-how is working full time, developing new refractory metals, to meet tomorrow's needs.





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PRIME MANUFACTURERS OF REFRACTORY METALS ENGINEERED FOR THE JOB

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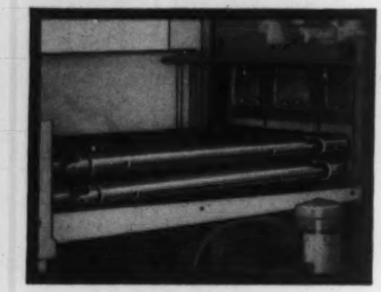
C-717

HOW CURTIS SOLVED A CLOSE CENTER-TO-CENTER PROBLEM



The close center-to-center spacing of these drive spindles on a Sutton-Maust Precision Backed-up Roller Leveler created a tough problem for its manufacturer. He needed a universal joint strong enough to stand up under heavy rolling mill conditions, yet small enough to operate at such close quarters.

The answer was a Curtis universal joint! The maximum load carrying capacity and minimum torsional deflection of the Curtis joint was found to be completely satisfactory. And Curtis' famous Telltale Lock Ring construction permits quick disassembly for easier maintenance.

This is just one of the many power transmission problems solved by Curtis universal joints — size for size the *strongest* universal joints designed for industry. Selected materials, precision engineering, and 40 years' experience manufacturing universal joints exclusively make them that way.

WRITE FOR THE NEW CURTIS CATALOG, JUST PUBLISHED

14 sizes always in stock $\frac{3}{8}$" to 4" O.D.

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK CURTIS

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5 Birnie Ave., Springfield, Mass.
As near to you as your telephone

Circle 573 on Page 19

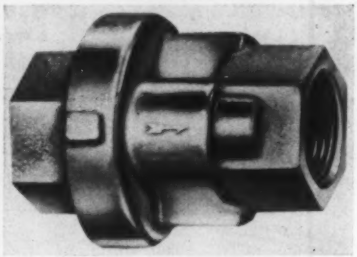
ness in all commercial widths and sizes. Foam is suited for furniture and automobile upholstery, bedding, packaging of delicate equipment, cushioning of aircraft components, and for a variety of insulation uses. **Plastics Div., Nopco Chemical Co.,** North Arlington, N. J. D

Circle 742 on Page 19

Flow Control

in 49 flow rates from 0.2 to 50 gpm

Flow-regulating device, designated L-P-D Mesurflo, automatically permits a specified rate of flow regardless of inlet pressures. Design provides low pressure drop, and unit operates noiselessly at any pressure. For hot or cold water, it is available in 49 flow rates from 0.2 to 50 gpm. Flow tolerances are maintained to 180 psi and temperatures to 160 F. Control is available in six pipe sizes from $\frac{1}{4}$ to $1\frac{1}{4}$ in. **Automatic Controls Div., Hays Mfg. Co.,** 450 W. 12th St., Erie, Pa. F



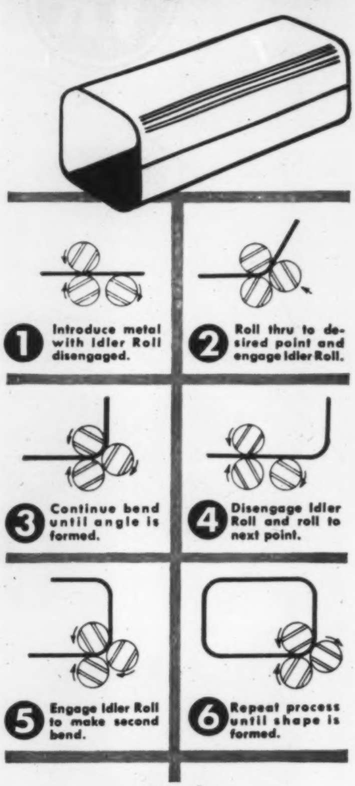
Circle 743 on Page 19

Pressure Switch

for machine-tool hydraulic systems

Oiltight pressure switch is for heavy-duty industrial applications on machine-tool hydraulic systems operating at pressures to 5000 psi. Switch has die-cast aluminum enclosure, completely sealed to exclude oil and water. Calibrated range scale and indicator show operating pressure, and visible trip indicator slows when contacts operate. Range adjustment changes both operating and reset pressure. Switch mechanism maintains high contact pressure to point of switch-over, no matter how slowly it is approached. Switch uses a bellows in five low

HOW TO FORM a rectangular shape



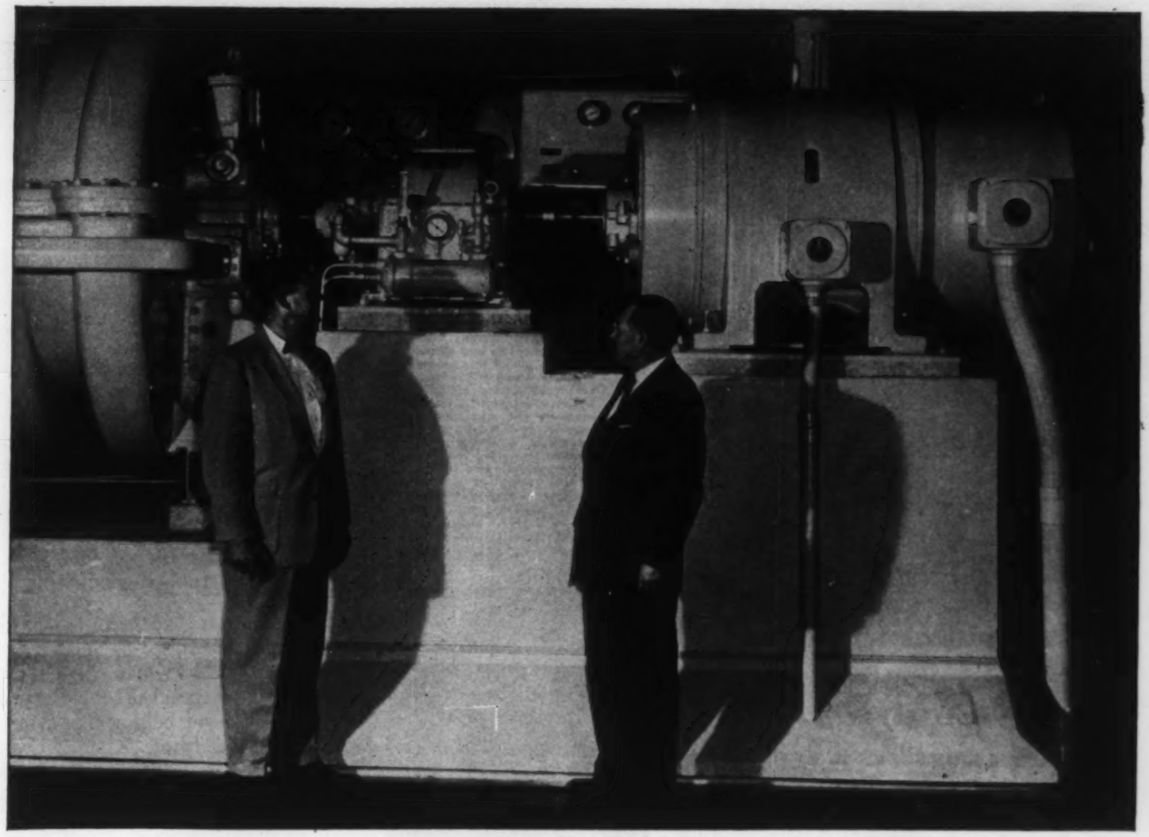
1 Introduce metal with Idler Roll disengaged.
2 Roll thru to desired point and engage Idler Roll.
3 Continue bend until angle is formed.
4 Disengage Idler Roll and roll to next point.
5 Engage Idler Roll to make second bend.
6 Repeat process until shape is formed.

with the DI-ACRO ROLLER

Forming small and large circles without flat spots and a variety of other sheet metal shapes is easily accomplished on the Di-Acro Roller with its *exclusive cam actuated Idler Roll.* Consult the yellow pages of your phone book for the name of your nearest Di-Acro distributor or write for six page instruction folder.

di-acro PRECISION METALWORKING MACHINES
pronounced die-ack-ro
O'NEIL-IRWIN MFG. CO.
416 Eighth Ave. • Lake City, Minn.

Circle 574 on Page 19



One of two Fairbanks-Morse 4160 volt, 700 hp. slip ring motors which power Carrier refrigeration compressors.

8-speed climate with F-M motors!

Flexible control of new air conditioning system saves power and maintenance for Union Oil Center

Through a new Carrier dual-duct high-velocity system powered by Fairbanks-Morse slip ring motors, the magnificent new Union Oil Center in Los Angeles is ideally air-conditioned at minimum power and maintenance cost.

Providing 8 speeds between 75 and 100 percent of capacity, the two F-M 700 hp. motors make it possible to match operating rpm. of compressors, chillers and condensers to any specific condition. The new Center covers 5 acres, with 1200 employees occupying 426,000 square feet of the office space in a complex of four buildings—an installation requiring the finest in air-conditioning equipment and components.

Fairbanks-Morse offers the distinct advantage of a broad range of alternating and direct current motors, in all types, and in ratings from ½ to 10,000 hp.

For expert assistance in specifying, write Fairbanks, Morse & Co., 600 South Michigan Ave., Chicago 5, Illinois.

New Union Oil Center in Los Angeles.

FAIRBANKS-MORSE

a name worth remembering when you want the BEST

ELECTRIC MOTORS · GENERATORS · PUMPS · SCALES · DIESEL, DUAL FUEL AND GAS ENGINES · LOCOMOTIVES · COMPRESSORS · MAGNETOS · HOME WATER SYSTEMS

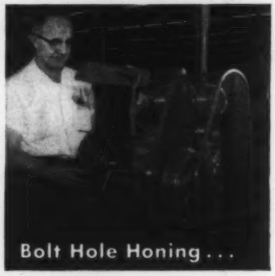
FAIRFIELD FACILITIES ... at Your Service

Gear Balancing . . .

Left—High accuracy balancing of rotating parts, including unusual off-center and counterweighted designs, can be handled rapidly and efficiently with the aid of this ingenious machine which utilizes stroboscopic light to locate the unbalance, an electric meter to measure the amount of unbalance, and a drill, mounted integrally, to remove indicated amount of metal for desired balance—followed by immediate inspection—all completed in a single handling.

Below—Other examples of specialized equipment "at your service" at FAIRFIELD.

Gear Tooth Honing . . .


Bolt Hole Honing . . .

—to give you
1. TIME SAVINGS
2. LOWER COSTS
3. BETTER GEARS

At Fairfield, YOUR GEARS are in the hands of specialists equipped with every facility for handling production RAPIDLY, EFFICIENTLY, and ECONOMICALLY. Special or unusual requirements in design, size, finish, tolerances, processing, materials, and heat treating are often "standard" at FAIRFIELD.

Fairfield's gearmaking facilities save capital investment for many builders, large and small, of power driven equipment. At Fairfield, you get the benefits of high production rates and big volume output in an ultra-modern plant designed exclusively for producing fine gears. *Become a Fairfield customer; it pays!* CALL OR WRITE.

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MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

Circle 576 on Page 19

pressure ranges to 500 psi, and piston design for systems to 5000 psi. **Allen-Bradley Co.,** 136 W. Greenfield Ave., Milwaukee 4, Wis. K

Circle 744 on Page 19

Rayon Yarn

for reinforcing mechanical rubber goods

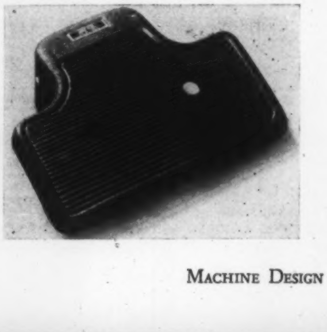
High-tenacity, adhesive-finished rayon yarn, identified as Super Cordura Type 272-F, is available for reinforcing mechanical rubber goods such as conveyor belting and wrapped and braided hose. Material can be processed on conventional industrial weaving equipment, and embodies advantages of adhesion without necessity for fabric dipping. Close control of fabric construction is possible through elimination of shrinkage which can occur in conventional fabric dipping. Material has high strength and good wet and dry adhesion. **Textile Fibers Dept., E. I. du Pont de Nemours & Co..** Wilmington 98, Del. C

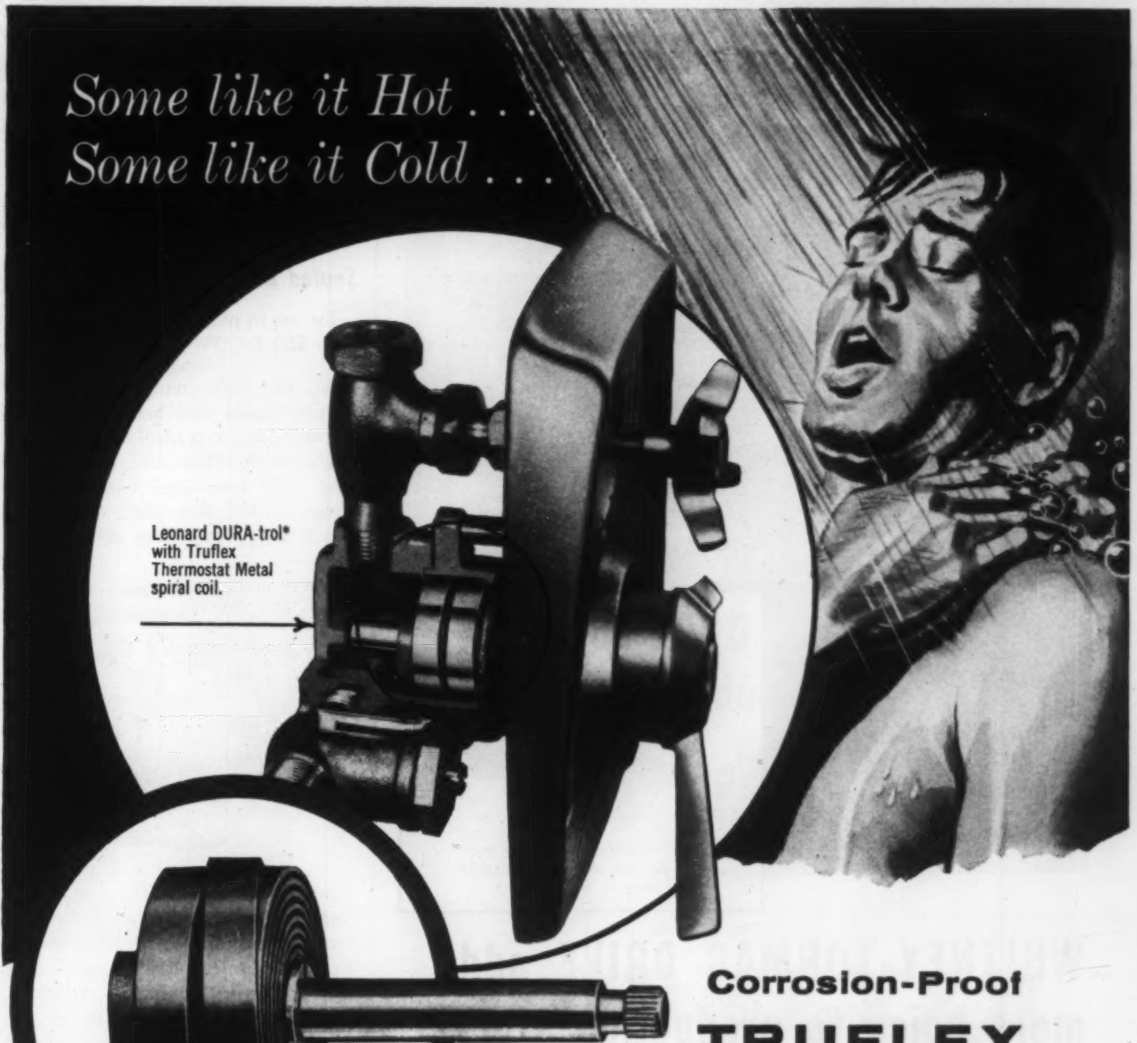
Circle 745 on Page 19

Foot Switch

has wide treadle

Clipper foot switch is available in both momentary and maintained-contact types, with single-pole, double-throw or double-pole, double-throw circuits. Two mounting holes are provided if rigid mounting is desired. Switch has




Some like it Hot . . .
Some like it Cold . . .
Leonard DURA-trol* with Truflex Thermostat Metal spiral coil.

Corrosion-Proof
TRUFLEX
Thermostat Metal enables Leonard Showermaster* to hold water temperature exactly

Like a duck takes to water . . . that's how General Plate Truflex Thermostat Metal withstands corrosion in all kinds of water. Take, for example, the DURA-trol element in the Showermaster manufactured by Leonard Valve Company. This double spiral coil, made from corrosion-proof Truflex Thermostat Metal, provides continuous control of water temperature. Mr. Everett C. Wilcox, President, puts it this way: *"Dependability and durability are prime requisites of our DURA-trol thermostatic element which must respond to temperature changes instantly and accurately. Truflex Thermostat Metal in this element has earned an outstanding record for complying with our high performance standards, even when subjected to the most adverse water conditions."*

**Registered trade marks of Leonard Valve Company*

You, too, can obtain constant and accurate temperature control, compensation or indication in your products with Truflex Thermostat Metal, parts or assemblies, fabricated to your exact specifications. Every Truflex order comes to you a precise duplicate of the original . . . consistently uniform in tolerances, temperature reaction and performance, thus preventing rejects and costly adjustments in assembly. The complete Truflex line includes 60 types of thermostat metal with resistivity from 15 to 850 ohms per c.m.f. Write for catalog.

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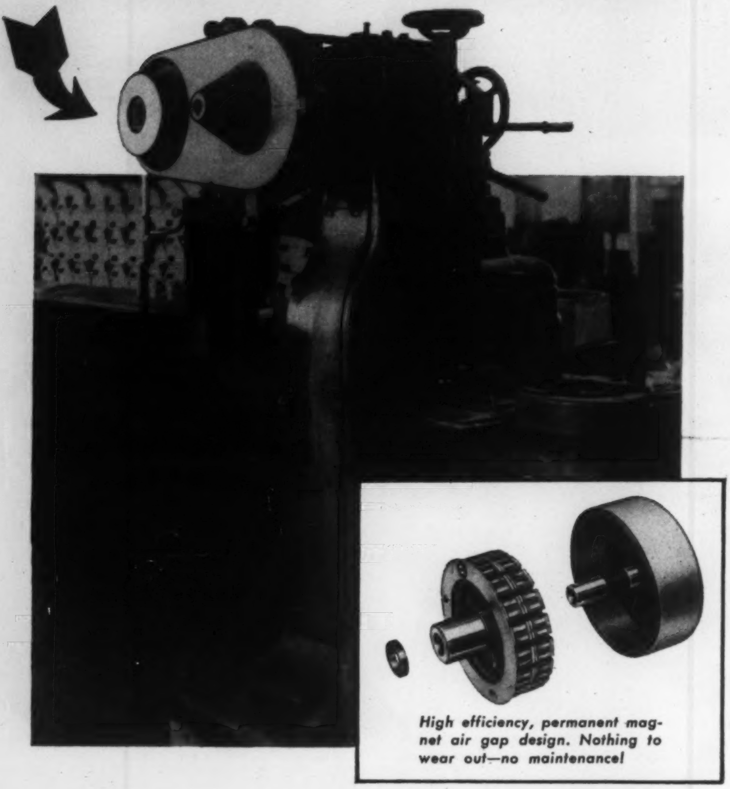
GENERAL PLATE PRODUCTS: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal • Platinum Metals • Reactor Metals • Radio Tube & Transistor Metals

NO MORE JAMS or BREAKAGES!



High efficiency, permanent magnet air gap design. Nothing to wear out—no maintenance!

WHITNEY-TORMAG DRIVE adds more spice to production story!

Gorman, Eckert & Company, Ltd., of London, Canada, were faced with a real time- and money-consuming problem. The high speed, automatic Die Seamer pictured above is used for sealing cans of Club-House Spices. Whenever the machine would jam, the chuck or other parts would break. This caused expensive and irritating downtime, plus the cost of spilled product, repairs or replacing the broken parts.

A Whitney-Tormag Magnetic Drive was finally installed on the Die Seamer's 2 H.P. motor and has completely eliminated broken parts and production tie-ups. The unique slip-drive characteristics of Whitney-Tormag Drive absorbs the shocks and overloads caused by jamming and protects the equipment until the operator clears the machine.

If your equipment is exposed to stalls, jams and overloads, you'll find the many advantages of the Whitney-Tormag Drive worth investigating. These modern, protective drives are answering these needs in every industry.

CHECK AND COMPARE THESE COST-REDUCING FEATURES:

- **RUNS AT FULL STALL** without harming motor or driven element.
- **SLIP-START DESIGN** permits lower H.P. motors—cuts motor, starter and power costs.
- **CUSHIONED STARTS** eliminate shock, reduce maintenance costs.
- **NO POWER LOSS** in fluids, particles or seal friction . . . nothing to freeze or boil.

Write for new catalog, giving range of sizes and complete details.

Whitney
CHAIN COMPANY
A SUBSIDIARY OF FOOTE BROS. GEAR AND MACHINE CORPORATION
414-C HAMILTON STREET • HARTFORD 2, CONN.
ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVES

Circle 578 on Page 19

wide treadle for convenient operation. It has high electrical ratings and incorporates a molded nylon actuator. **Linemaster Switch Corp.**, 432 Woodstock Terrace, Woodstock, Conn. B

Circle 746 on Page 19

Sealed Ball Bearings

for use in temperatures to 550 F

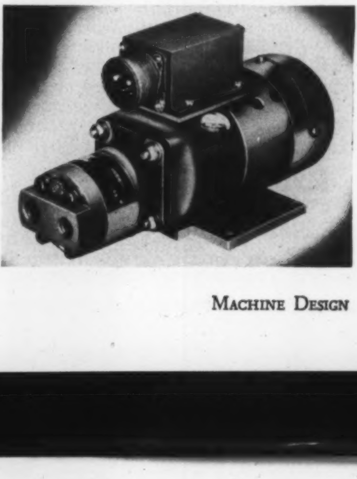
AW - AK high - temperature, low-torque, sealed ball bearings are for use in aircraft control applications. They are stainless steel, heat stabilized, and lubricated with heat-resistant oil. Teflon fabric seals withstand temperatures to 550 F and hold seal drag to a minimum. Stainless-steel ball separators insure extremely low torque. Bearing widths to close tolerances permit easy mounting in standard brackets. **Fafnir Bearing Co.**, 37 Booth St., New Britain, Conn. B

Circle 747 on Page 19

Hydraulic Pump

has capacity of 0.2 gpm at 3000 psi outlet

Lightweight, compact, piston-loaded gear pump meets military and commercial requirements of long life and dependability. It has capacity of 0.2 gpm minimum at 3000 psi outlet. Unit meets MIL-P-5954A



and has total weight of 7.9 lb. Motor, 28 v dc, is fully enclosed and is explosion-resistant, fan-cooled type. It conforms to MIL-M-8609. **Great Lakes Mfg. Corp.**, 4223 Monticello Blvd., Cleveland 21, Ohio. F

Circle 748 on Page 19

Speed Reducers

can be operated over
wide range of speeds

Shaft-mounted speed reducers are designed for quick, easy installation to driven shaft and require minimum mounting space. They use standard V-belts and pulleys, and are equipped with a torque arm for easy, infinite belt adjustments. Units can be operated over a wide range of speeds by using a variable-pitch pulley or by changing sheave combinations. Capacities range from 1 to 40 hp with single-reduction gearing and output speeds from 90 to 420 rpm, and from 1 to 30 hp, with double-reduction units and speeds from 10 to 160 rpm. Flange-mounted type with double-reduction gearing is also available with capacities from 1 through 7 hp and speed range from 10 to 135 rpm. **Lima Electric Motor Co. Inc.**, Dept. 139, Lima, Ohio. G

Circle 749 on Page 19

Small Tubing

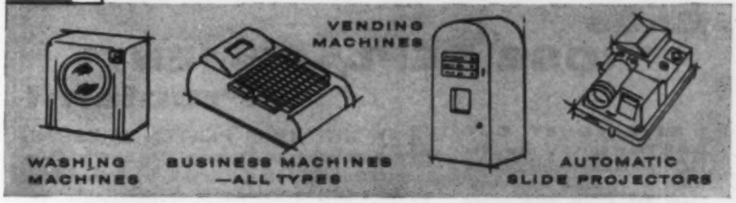
of A-286 austenitic alloy
resists corrosion

For use in high-temperature applications to 1300 F, small tubing of A-286 alloy is available. Alloy has excellent oxidation resistance, and shows excellent corrosion resistance against all atmospheres encountered in gas-turbine service. It also has outstanding properties at subzero

this miniature solenoid . . .

or this one . . .

can do a BIG job for a long, long time in products like these . . .



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folded frame solenoids

- **Compact,** built rugged for severe duty
- **Simple design,** quality materials and fabrication
- **Low unit cost** plus dependable performance returns more control "mileage" per dollar spent
- **Double shading coils** deliver high seating pull without hammer, without excessive AC hum or chatter
- **No Power drop-off**—plunger's stroke is phase-timed for the maximum load
- **Critical tolerances,** uniform electrical characteristics

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for data-packed catalog

SOLENOIDS
COILS
TRANSFORMERS
DORMEYER Industries

- **Immediate delivery** . . . constant or intermittent duty types . . . pull capacities up to 5 lbs. . . . strokes to ½" . . . single units or cost-saving production runs • **Specials custom engineered** for the job—prompt estimates on receipt of print or specifications

Other Solenoids for all applications, Quality Transformers, Coils

DORMEYER INDUSTRIES
3434 MILWAUKEE AVENUE • CHICAGO 41, ILLINOIS

Circle 579 on Page 19

-Installs
BARCO
Self-Aligning
SWIVEL
JOINTS
CHARDON RUBBER CO.
Chardon, Ohio

Ends "HOSE REPLACEMENT" Problem!

1. SAVE MONEY! CUT COSTS—Barco's new No. 11CTS gasket is amazingly long wearing! Does not bake hard. Ideal for steam and water service. Does not cause excess wear on other parts.

2. LEAKPROOF, HOT OR COLD—Joints stay tight regardless of pressure or temperature.

3. SELF-ALIGNING—10° side flexibility. This Barco feature saves piping time, cuts costs, and insures perfect performance.

4. ENGINEERING RECOMMENDATIONS—Send for a copy of Catalog No. 265C and installation drawing 10-52004.

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BARCO
SWIVEL JOINTS
for Piping

SEND
FOR CATALOG 265C

43 MULTIPLE PLATEN PRESSES running 24 hours a day and cycling every 3 to 5 minutes, 6 days a week, can add up to a BIG maintenance responsibility! In checking records, ALEX J. KELLER, Plant Manager, The Chardon Rubber Company, Chardon, Ohio, found he was having a continual series of emergencies with steam hose connections breaking unexpectedly.

Because of LOSS of time, LOSS of steam, LOSS of production, and COST of hose, Mr. Keller decided to make a test installation using Barco Type S Swivel Joints WITH NEW 11CTS TEFLON SEALS, and all-metal dog-leg piping. Each line is precisely positioned for perfect steam flow, with no "low spots" to trap condensate. Lines "nest" together when press is closed, yet move readily without interference when press opens.

The test was a real revelation! Today, Chardon Rubber Co. has all 43 presses equipped with Barco Swivel Joints. Operating experience has demonstrated that the joints stay tight without leakage and with no danger of blow-outs. When desired, the joints easily handle alternate flow of hot steam and cold water. There has been no maintenance time on the 387 joints since installation.

IT PAYS TO USE
BARCO SWIVEL JOINTS!

PRODUCTS BACKED BY EXPERIENCE
BARCO
FOUNDED 1908

BARCO MANUFACTURING CO.
506G Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

Circle 580 on Page 19

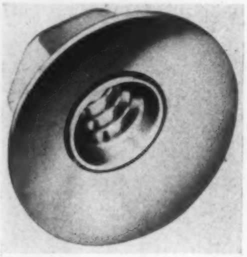
temperatures, and low magnetic permeability. Material is low in strategic alloy content. Tubing is suitable for a variety of industrial applications where strength and oxidation resistance at high temperatures are required. It is available as either seamless or Weldrawn. Standard production limits are 0.012 to 0.625-in. OD for seamless A-286, and 0.0625 to 0.625-in. OD for Weldrawn grade. Solution-annealed, half-hard, and full-hard tempers are supplied. **Superior Tube Co.**, 1578 Germantown Ave., Norristown, Pa.

Circle 750 on Page 19

E

Nuts and Washers

preassembled units are for spanning bolt holes



Two types of Keps preassemblies include plain dished-washer units and conical washer types. They are recommended for spanning bolt holes and distributing fastener load around and away from hole. Units are available in sizes from No. 8 to 5/16, with various washer sizes. **Shakeproof Div., Illinois Tool Works**, St. Charles Road, Elgin, Ill.

Circle 751 on Page 19

Bonding Alloy

bonds carbide to steel or other metals

Plymet alloy, in the form of thin wafers, joins cemented carbide to steel or other metals. Alloy produces joints with rupture strength from 100,000 to 135,000 psi, several times stronger than brazed joints. Joint is shock resistant and economical to make. Material is self-fluxing. It is available in thin, round discs, but can also be made to special shapes upon request. **Powder Alloys Corp.**, 316 Colfax Ave., Clifton, N. J.

D

Circle 752 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Straight Edges

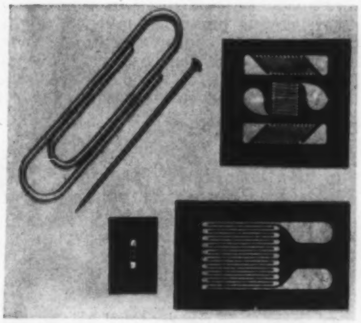
plastic units are
⅛ or 3/16 in. thick

Plastic straight edges have optically flat surfaces, are light to move on drawing board and to carry, are fully transparent, and will not soil or mar a drawing. No. P5700 and P5800 units are ⅛ and 3/16 in. thick, respectively. They have one beveled and one square working edge, both with chamfer of approximately 0.01 in. Straight edges have rounded corners, chamfered for approximately 0.03 in. to reduce breakage. Width of unit varies with length. Lengths range from 18 to 46 in. **Dolgorukov Mfg. Co.,** 407 Fisher Bldg., Detroit 2, Mich. H

Circle 753 on Page 19

Strain Gages

with high fatigue life
are 0.001 in. thick



Three tiny strain gages range from 1/32 in. wide and 5/32 in. long to ½ in. square. They are 0.001 in. thick and weigh from 1.1 to 9.3 mg. Included are rosette gage to determine magnitude and directions of principal strains, a miniature gage for use in areas of very steep strain gradient, and high-fatigue life gage for structures undergoing severe dynamic strain. No. 121-R3A rosette gages (top) are temperature compensated for steels, 18-8 stainless steels, magnesium alloys, and

This can't be FIREBAN...

New Taylor FIREBAN 321 Laminated Plastic is self-extinguishing in only 3 seconds

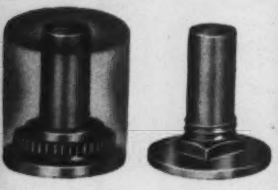
Electrical faults in appliances, TV sets, radios, motors and other electrical devices frequently lead to fires—and these fires lead to complete destruction of the equipment, sometimes extensive damage to the facilities surrounding it. Taylor FIREBAN 321 is designed to retard fire. Self-extinguishing in only 3 seconds—it is an effective barrier against the spread of flame. In addition, this flame-retardant laminated plastic has excellent moisture resistance, excellent electrical resistance after exposure to high humidity, and good mechanical properties; also offers low dielectric losses. These properties help prevent the electrical faults that lead to fires. Write TAYLOR FIBRE CO., Norristown 47, Pa., for complete details.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

Circle 581 on Page 19

A
SAVING
OF
OVER $40.00
per thousand pieces



MILLED FROM BAR COLD HEADED

thanks to
COLD HEADING
by
CLARK

THE PROBLEM:
Cut costs on a special fastener blank used as insert in plastic knob.

SPECIAL REQUIREMENTS:
Fastener must have surfaces that grip into plastic and hold fast when knob is pulled laterally or turned.

SOLUTION:
Redesign to simplify gripping surfaces. Production by Clark Cold Heading process (instead of machining from bar stock).

SAVINGS:
In steel . . . . $19.70 per 1 M pcs.
In labor, over 21.00 per 1 M pcs.
TOTAL, over $40.00 per 1 M pcs.

It's quite possible that Clark Cold Heading can effect equally impressive savings on *your* special fasteners.

Send sample (or blueprint) for prompt analysis and quotation . . . *at no obligation.*

CLARK
BROS. BOLT CO.
MILLDALE, CONN.

Circle 582 on Page 19

aluminum. They are epoxy-backed and at least 1/16 in. of border material is supplied on all sides of rosette pattern. No. 1X1-32A miniature gages (left) have maximum temperature limit of 200-250 F. Epoxy-backed, they are also temperature compensated for the four alloys. Series 301 dynamic strain measurement unit (right) has high gage factor (approximately 3.2) and maximum endurance limit. It is not available in temperature-compensated types. **Tatnall Measuring Systems Co.**, Box 245, Phoenixville, Pa. E

Circle 754 on Page 19

Photocopy Processor

utilizes two separate processing solutions

Quick Silver processor is used to process copies which have been exposed on other types of photocopy printers. It uses silver-photography stabilization process by which only a single, sensitized sheet of paper is used to make a copy. Process makes either one or many copies quickly and economically from a single original. Superior quality reproduction with high image density and long life is obtained by use of two separate processing solutions. Processor, designated Model 1500, is a desk-top unit which takes sheets up to 9 in. wide of any length. Unit can be used conveniently in a variety of positions. **Peerless Photo Products Inc.**, Shoreham, L. I., N. Y. D

Circle 755 on Page 19

Photographic Tape

in widths from 0.015 in.

Black pressure-sensitive photographic tape with clear adhesive is available in precision tolerance widths

PUMP
DESIGN
TRENDS
by Arthur A. Nichols

"BUILT-IN PUMPS"
SIMPLIFY MACHINE DESIGN

Designers of machines employing lubricating pumps or low-pressure hydraulic systems can now achieve more compact design and reduced costs by integrating three matched Gerotor pump components directly into their mechanism. This space-saving innovation is now widely specified for machine tool, automotive, aircraft and other fluid systems.

Consisting of an inner and outer Gerotor and an eccentric locator-ring, the unit becomes a complete pump by simply boring the casting or frame of the mechanism to accommodate the locator ring O.D. and by providing porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft. *(Fig. 1.)*

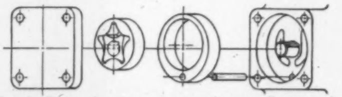


Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

The Gerotor pump is a positive displacement type, delivering a predetermined amount of fluid in direct proportion to speed. It is a form of internal gear pump — simple and compact in basic design, (has only two moving parts). It is light-weight, valveless, provides exceptional performance and has low wear over a long service life. It is balanced and extremely quiet in operation. *(Fig. 2.)*

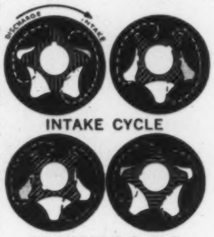


Fig. 2 Gerotor pump operating principle.

The matched elements are as easily built-in as a simple anti-friction bearing would be. Further, the Gerotor pump is extremely flexible in its configuration and readily adapts to a wide variety of mechanism geometries. It will handle a variety of fluids at rates up to 100 gpm and pressures up to 1,000 psi.

Investigate this cost saving development. Just send us information about the fluid you want to handle, rate of flow, pressure and dimensional limits. We'll provide specific recommendations, estimated costs and technical data.

W. H. NICHOLS CO.
38 Woerd Ave., Waltham 54, Mass.

Circle 583 on Page 19

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER GUIDANCE–
VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

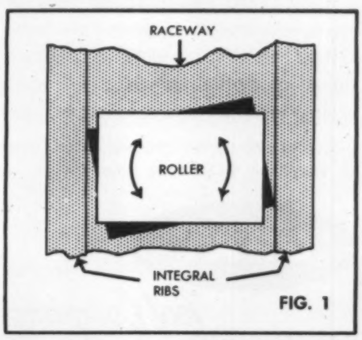


FIG. 1

Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!

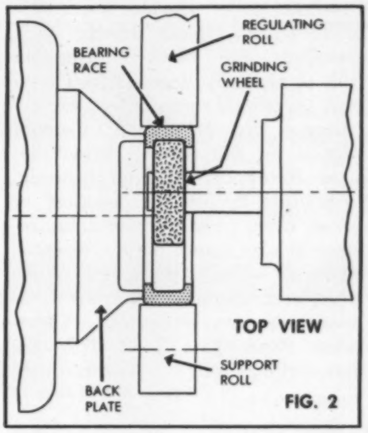


FIG. 2

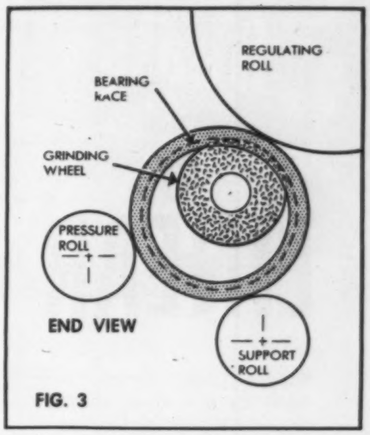


FIG. 3

Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.

* * * *

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 584 on Page 19

V Ring Seals by LINEAR

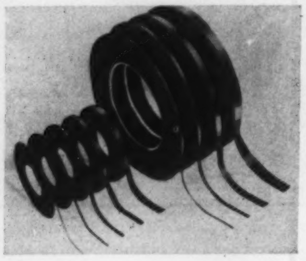
in Kel-F, Viton-A, Vyram, Polyurethane, and other unusual elastomeric materials having excellent resistance to many petroleum oils, synthetic lubricants, fuels, phosphate and silicate ester fluids—in a temperature range of —40° to +500° F.

LINEAR—specialists in close-tolerance molding in all of today's modern polymers . . . in both fabric reinforced and homogeneous materials.

These are automatic seals. For further help, call the LINEAR engineer.

PERFECTION IN RUBBER
LINEAR
LINEAR Inc. STATE ROAD & LEVICK ST., PHILA 35, PA

Circle 585 on Page 19



from 0.015 in. and up, to any fraction of an inch in 15 and 60-yard rolls. Tape is backed with clear, nonstaining adhesive, and is ideal for making printed-circuit master layouts. Tape is also available in rolls 3 in. wide by 5 yards long. **By-Buk Co.**, 4314 W. Pico Blvd., Los Angeles 19, Calif. L

Circle 756 on Page 19

Drafting Paper

provides preprints of recurring details

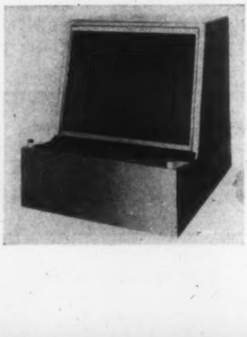
Pre-Print paper provides a preprint of recurring typical details, basic standards, title block information, bills of materials, legends, and symbols. Optional items of frequent recurrence are printed in Fadeout process on the paper. When desired to appear in final printing, preprinted details are pencilled or inked over. Fadeout lines on reverse side of paper permit repeated erasures without destroying guide lines, and disappear when drawings are made into blueprints. **Clearprint Paper Co.**, 1482 67th St., Emeryville, Calif. M

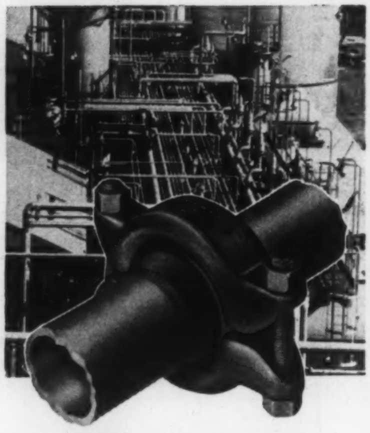
Circle 757 on Page 19

Filmcard Reader

has 18 x 24-in. plastic-crystal screen

Designed for engineering drawings and other large size documents copied on 35-mm microfilm, KG 15 reader features an 18 x 24-in. screen





GRAYLOC

New Principle of Pipe Connections

Two-bolt GRAYLOC Pipe Connections introduce a new principle in pipe make-up. Its design makes it possible for GRAYLOC to withstand full vacuum, high external pressure and extreme internal pressure. Moreover, this design makes it possible to make up GRAYLOC Connections repeatedly with no wear or other damage to the connections.

The bolting carries no primary force from internal pressures. Two bolts serve only to pull the connection together through the wedging action of the clamp and the seal ring.

Flexible tapered lips of the seal ring are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect.

GRAYLOC has practical uses in any application where flanges are used. GRAYLOC is recommended where pressures are high or where you want savings in money, space, weight or time.

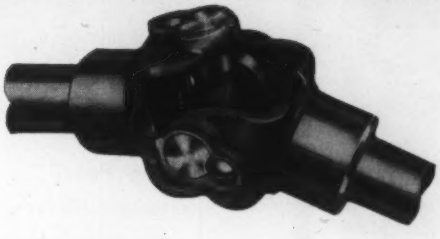
For additional information, write, wire or telephone Gray Tool Company.

GRAY Tool Company

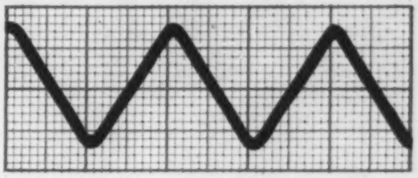
P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641 5903

Circle 586 on Page 19

3-minute "post-grad course"
IN TORQUE TRANSMISSION

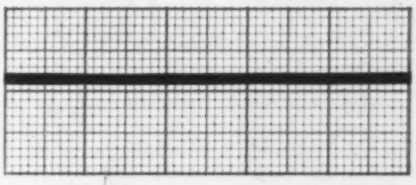


ORDINARY CARDAN UNIVERSAL JOINT



Mathematics and geometry prove this design joint continually changes shaft output velocity. During each revolution there are two high points, and two low points of speed and torque variation. This fluctuating torque action causes vibration and wear throughout entire driving mechanism.

CONSTANT VELOCITY JOINT



This RZEPPA design joint *continually* transmits 100% smooth torque at all joint working angles. Such smooth torque action results from the drive balls applying force in a plane that bisects both input and output shaft axes.

Do you have a torque transmission problem that requires any one or a combination of these design improvements:

Less vibration	*Higher speeds*
Reduced bearing wear	*Greater angles*
Longer shaft life	*More capacity*

And, if your application warrants placing the solution and ultimate cost-savings above ordinary, lower priced joint designs . . . RZEPPA can help you.

RZEPPA Constant Velocity Joints are available for *light*, *medium* and *heavy* duty applications on air and space craft, vehicles and industrial machinery.

WRITE FOR LATEST LITERATURE or send your dimensional sketch along with peak horsepower, R.P.M. and operating angles. Without obligation, our engineers will assist you. Address: THE GEAR GRINDING MACHINE CO., Dept. DJ-659, 3901 Christopher Street, Detroit 11, Michigan.

(PRONOUNCED: "SHEPPA")

RZEPPA

CONSTANT VELOCITY UNIVERSAL JOINTS

Genuine RZEPPA Joints are made exclusively by THE GEAR GRINDING MACHINE CO.

Circle 587 on Page 19

Chace THERMOSTATIC BIMETAL
Actuates Another Precision Product

THE G.E. GUARDETTE

A PRODUCT OF GENERAL ELECTRIC APPLIANCE CONTROL DEPARTMENT MORRISON, ILLINOIS

The Guardette is a motor protection device of numerous and varying applications. Manufactured by General Electric Company's Appliance Control Department, the Guardette protects the motor from over-heated windings under locked rotor or any condition of overload. It is used for appliances, such as washers, dryers, disposals and dishwashers; for hermetic motors in refrigerators, freezers and room air conditioners; and for general purpose motors. With space saving such an important factor, the Guardette offers only 1" diameter. In addition it provides easy mounting, a wide range of adjustment, precise calibration, dependability in performance and long load life.

The list of manufacturers specifying Chace Thermostatic Bimetal reads like the "400" in American industry. But large or small, prominent or momentarily little-known, all are super-critical of the often minute bit of metal upon which the action of their product depends. A variation of a few degrees in the response of a motor protector can mean total destruction of the equipment, perhaps a much larger loss. That's why critical buyers look to Chace year after year for thermostatic bimetal which is uniform in its alloys, uniform in its processing, uniform in its precision production methods, uniform in its inspection procedures. Chace's maintenance of excellent relations with the world's most particular buyers for over a third of a century proves we and they are on the right track.

When your new temperature responsive device approaches the design stage remember that Chace Thermostatic Bimetal is available in strip, coil or completely fabricated and assembled elements of your design. Send for "Successful Applications of Chace Thermostatic Bimetal," containing many pages of design data.

IT BENDS WITH THE HEAT
W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

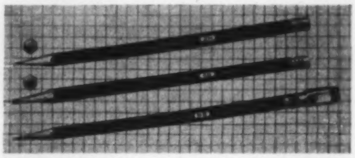
Circle 588 on Page 19

made of plastic crystals. Even, brilliant screen image is provided by 500-w lamp. Fingertip controls are located in front of reader for maximum operator efficiency and comfort. Entire Filmsort D-aperture card can be projected without need for scanning. Adapter is available to project roll film. Special provision permits making full-size photo prints. **Micro-Fax Div., Eugene Dietzgen Co.,** 218 E. 23rd St., New York 10, N. Y. D

Circle 758 on Page 19

Drafting Pencil

has adjustable eraser



Microtomic No. 603 drafting pencil incorporates flat ferrule of high-luster chrome banded in black enamel, containing an adjustable pink pearl eraser. Pencil lettering is bright aluminum to match ferrule. Eighteen degrees from 7B to 9H are furnished. **Eberhard Faber Pencil Co.,** Crestwood, Wilkes-Barre, Pa. E

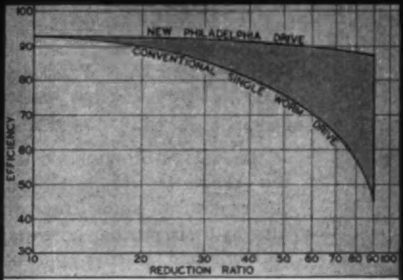
Circle 759 on Page 19

Triaxial Accelerometer

measures vibration in
three axes simultaneously

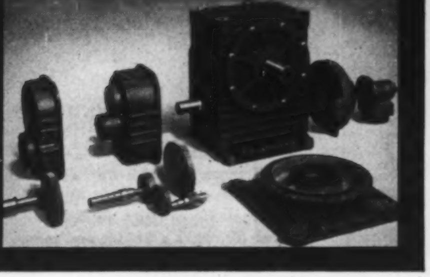
Model 2223 triaxial accelerometer consists of three Piezite Type 1 sensing elements mounted in mutually perpendicular planes within a $\frac{5}{8}$-cu. in. block. Weighing 1.4 oz, the unit provides accurate, simultaneous measurement of vibration in three axes. Accelerometer operates over a temperature range of -65 to 220 F with maximum change in sensitivity of ± 10 per cent. Frequency response is 2 to 2000 cps ± 5 per cent with 1000-megohm load. Each separate axis is individually calibrated 20 to 4000 cps ± 5 per cent before installation in triaxial block. Case is electrically isolated from stray ground loops in test structures. **Endevco Corp.,** 161 E. California Blvd., Pasadena, Calif. L

Circle 760 on Page 19



Shaded area shows gain in power consumption.

New design standardization permits fast assembly and shipment from stock of any size and ratio with any mounting and drive arrangement.



NOW get new efficiency new savings in weight and space in worm gear drives

New high efficiency. These new drives offer efficiencies never before available in worm gear drives. Helical attachments for double and triple reduction units combine the efficiency advantage of helical gearing with the high ratio advantage of worm gearing. You save on power consumption . . . operating temperatures are lower . . . gearing lasts longer.

New high capacity. This is not just a re-rated line. Improved tooth forms, precision ground alloy steel worms, special high strength bronze gears, sturdy housings, precision ground helical gearing . . . all mean higher capacity in less space. In fact, you get space savings to 50% . . . weight savings to 60%. Or, you can handle loads up to 80% greater in the same space.

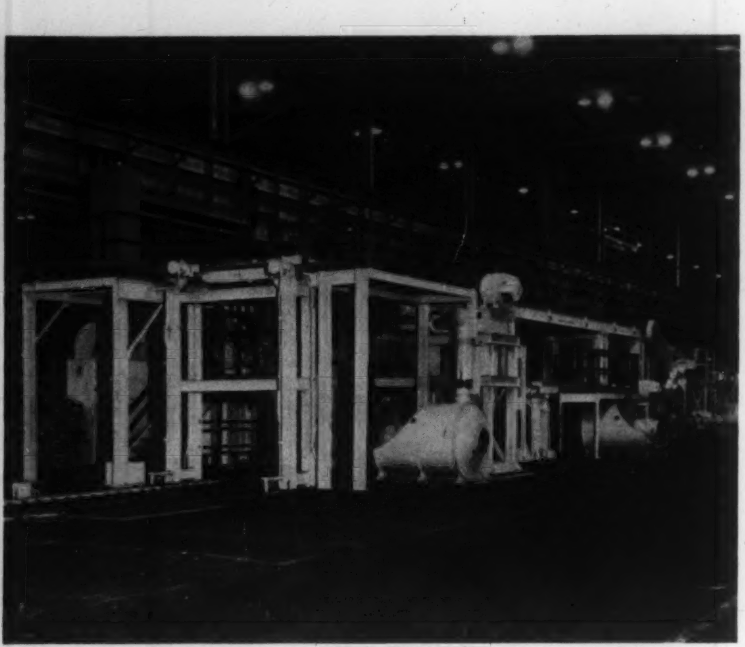
New flexibility. These new heavy duty high efficiency Philadelphia drives have a degree of flexibility never before available. One basic housing design can be combined with standardized horizontal and vertical mounting bases, worm gearing, single and double helical attachments, and fans, for any drive and mounting arrangement in the exact size and ratio to meet your requirements . . . standard or special. Torque control attachments for all sizes are available from stock for applications demanding overload protection. Ratios from 5⅛ : 1 to 1212 : 1. Center distances from 3″ to 21″. Write for catalog information.

PHILADELPHIA GEAR CORPORATION
Erie Avenue and G Street • Philadelphia 34, Penna.

philadelphia gear drives

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS



Blaw-Knox Company, Aetna-Standard Division's sheet piler at a large eastern steel plant.

An "Air Cushion" Created by

SPENCER Blowers

Solved this Designer's problem

Designing this sheet piler—which handles cold rolled sheets on the world's highest tonnage shearing line–posed many problems. A particularly tough one: how to handle piling of the sheared sheets.

The designer's imaginative and practical solution: an "air cushion" created by Spencer blowers. Sheared sheets "float" down into position. Surface scratching is kept at a minimum . . . production is speeded.

Possibly Spencer blowers (or vacuum producers) can help solve *your* difficult design problem. We invite your inquiry–at no obligation.

Standard Capacities of Spencer Blowers

1/3 H.P. to 1,000 H.P.
Up to 20,000 C.F.M.
4 oz. to 10 lbs. pressure

SPENCER
TURBO COMPRESSORS

Request Catalog 126B containing complete information on Spencer blowers.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

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THE ENGINEER'S

Library

Recent Books

Symbolic Logic and Intelligent Machines. *By Edmund C. Berkeley; 203 pages, 6 by 9 in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* Machine Design, *$6.50 per copy postpaid.*

This basic book attempts to clarify the nature of symbolic logic and the properties of intelligent machines and to show their relationship to their mutual advantage. Also explained is the application of symbolic logic in the design of machines that behave intelligently. Boolean algebra and rules for calculating with it are presented. Principles, problems, and programming of both large and small machines are discussed.

Association Publications

IES Lighting Handbook, Third Edition. *1100 pages, 6 by 9 in., clothbound; published by and available from Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.; $10.00 per copy.*

This handbook is a detailed revision of the second edition published in 1952 and includes information not previously published by the Society. Higher recommended lighting levels based upon the Blackwell researches are tabulated. The 25 sections can be divided into basic reference information, lighting calculation and design, and lighting applications. Subjects include light measurement, control, and sources; interior and exterior lighting; miniature lamps; aviation lighting; and radar-screen lighting. Appendix contains manufacturers' reference data and an equipment directory featuring available fixtures, accessories, and materials.

New Standards

American Standard Y14.10-1959, Metal Stampings, American Drafting Standards Manual. *22 pages, 8½ by 11 in., paper-*

ORCO

"Customeered"
components
basic to industry

ideas on "Customeered" RUBBER PARTS

...their design and application for improved product performance **No. 1**

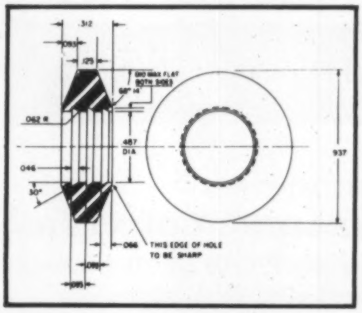
New ORCO continuous process now custom molds precision rubber parts in volume—at less cost!

Precise tolerances within ±0.003 in. are now possible in large volume production of custom-molded rubber component parts. Ohio Rubber's new high-speed, continuous molding process produces such parts at rates of up to 200,000 pieces per day.

Greater precision, which results in important savings on finishing costs, is assured through use of single-cavity, self-registering molds. They permit accurate, uniform application of pressure to minimize flash—maintain consistent tolerances for all dimensions. Uniform material thickness is equally assured by a plasticizing mill, which as an integrated part of the process directs uniform charges to each mold.

Wide range of parts being more economically produced through Ohio Rubber's new molding process include (top, left to right): valve stem deflector, condenser seal, (bottom) seal piston rod packing, universal joint seal, and oil seal. These, like all the many other small, *precision* parts already produced or being produced, vary in dimensions up to 1½" in diameter and 1" in thickness.

Direct feeding, from the mill to the mold wheel, eliminates the conventional intermediate extrusion step and further insures part uniformity and quality consistent with specifications. The continuous process permits *precise* control of time and temperature for each part.



High-precision is indicated in the close tolerances of this quadruple-landed seal for auto shock absorbers—more economically produced in volume through Ohio Rubber's new high-speed, continuous molding process.

Large volume production results in substantial cost savings for small, precision parts requiring tolerances obtainable by other precision molding processes. For parts formed by less precise, conventional methods, performance can be improved through greater accuracy—and without prohibitive increase in cost.

Quantity requirements involving 500,000 or more parts annually are recommended for most advantageous use of the new process. Since two similar parts of different size can be produced simultaneously by alternating the molds on the molding wheel, lower production runs which might not be economical can be combined with a separate order.

Complete information on this revolutionary new process is available in bulletin form. Send for your free copy today. At the same time, be sure to inquire about Ohio Rubber's complete component "Customeering" service—molding, extruding, and bonding-to-metal. Just mention ORCO Bulletin 715.

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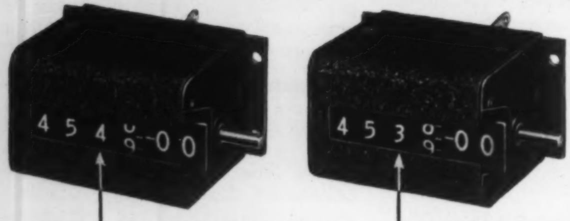

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bound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.50 per copy.

Stamping refers to pressworking of sheet metal to change its shape. Basic empirical layout and drafting practices are indicated. Dimensioning methods conform to Sections 5 and 16 of the manual.

Drafting procedures for stampings made by cutting material cover such processes as blanking, punching, trimming, shaving, burnishing, cutting off, and notching. Processes covered for forming material are bending, embossing, drawing, coining, swaging, extruding, ironing, necking, bulging, and curling. Proper treatment of material call-out and burrs is included.

Government Publications

NASA Publications. Copies of publications listed below are available from National Aeronautics and Space Administration, 1520 H St. N.W., Washington 25, D. C.

Memo 2-25-59E. Halogen-Containing Gases as Boundary Lubricants for Corrosion-Resistant Alloys at 1200 F. By Donald H. Buckley and Robert L. Johnson; 27 pages, 7¾ by 10¼ in., paperbound, side-stapled.

Iron, cobalt, and nickel-base metals were experimentally selected for their corrosion resistance to the reactive gases CF_2Cl_2, CF_3Br_2, CF_3Br, CF_3I, and I_2. Gases are decomposed by frictional heat and sulfur hexafluoride, SF_2, acting as a catalyst. Released atoms form metallic halides which serve as surface lubricants.

Friction, wear, and corrosion were studied in gas atmospheres from 75 to 1200 F. A 3/16-in. diameter hemisphere under a load of 1200 gm rode the flat surface of a rotating disk at sliding velocities of 120 fpm.

Memo 3-2-59E. Lubricating Properties of Lead-Monoxide-Base Coatings of Various Compositions at Temperatures to 1250 F. By Harold E. Sliney; 22 pages, 7¾ by 10¼ in., paperbound, side-stapled.

Formulations, application, composition, and structure analysis, as well as friction and wear studies, of various coatings are reported. Vitrifying oxide additions to PbO-base coatings include vanadium pentoxide and boric oxide. Bentonite clay and magnetite are also added. Effects of Inconel X and AISI 440-C and 304 stainless steel as base metals are studied. Sliding velocities of 430 fpm, normal load of 1 kilogram, and temperatures from 75 to 1250 F were used.

Memo 3-9-59E. Tensile Properties of Molybdenum and Tungsten from 2500 to 3700 F. By Robert W. Hall and Paul F. Sikora; 30 pages, 7¾ by 10¼ in., paperbound, side-stapled.

Commercially pure sintered tungsten and arc-cast unalloyed molybdenum, a commercial arc-cast molybdenum alloy containing titanium, and an experimental arc-cast molybdenum alloy containing titanium and zirconium were tested.

N-68112, v.1. Material Properties Handbook—Volume 1, Aluminum Alloys. Prepared by The Royal Aeronautical Society for the Advisory Group for Aeronautical Research and Development; pages are 8 by 10¼ in., loose-leaf cover.

International co-operation makes available this reference book on properties of aircraft structural aluminum as produced by the NATO countries of Canada, France, Italy, United Kingdom, and United States. Sections for each country include charts and data for room and elevated temperatures, alloy designation and specification, heat treatment, cladding thicknesses, and testing procedures.

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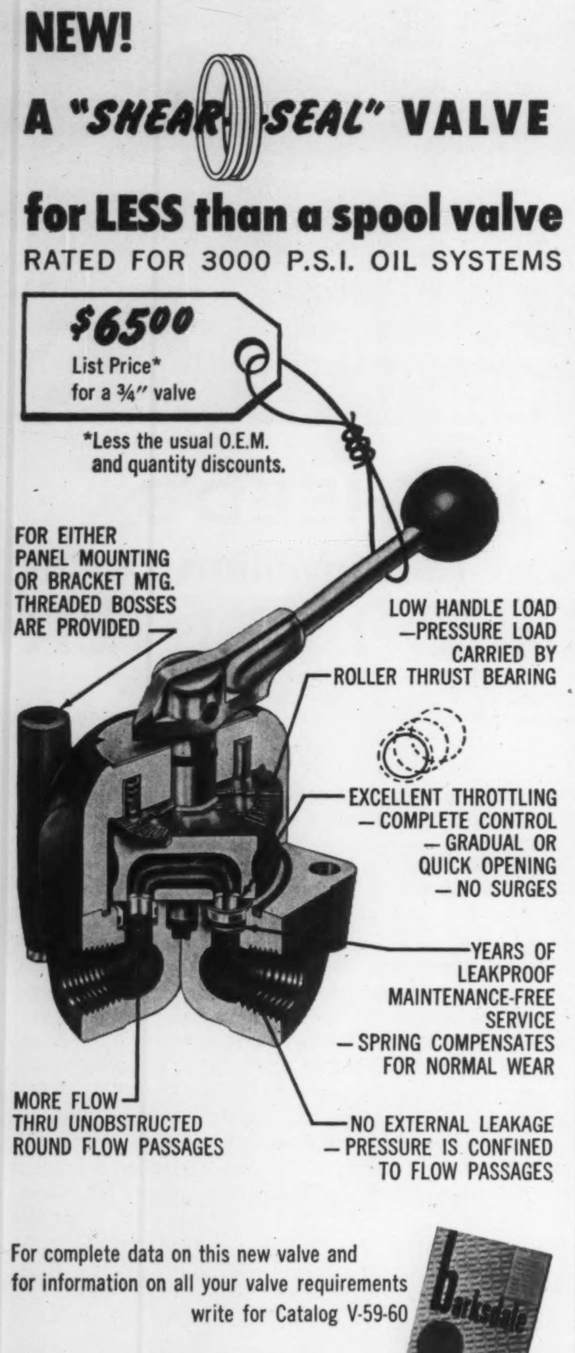

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Professional Viewpoints

. . . simplified drafting is not enough . . .

To the Editor:

Drafting is in a dilemma because draftsmen have not been able to increase their basic productivity appreciably in the last half century.

While corporations have spent vast sums of money harnessing the most modern machine tools for factory workers so that they could turn out more goods in fewer hours, the aids to drafting have been piddling by comparison. This has enabled production and other workers to demand—and get—higher wages. Draftsmen, on the other hand, have not been in a position to demand as much, and consequently they have fallen behind. This is the key to the shortage of personnel and the higher relative costs in drafting.

A panacea called "simplified drafting" has been suggested as a solution to this problem. The essence of simplified drafting is the reduction of needless embellishments to the point where an absolute minimum of manual and other labor is used to communicate information—usually between engineering and some other department within a company.

Most debates about simplified drafting have been fought over how far common sense can be carried in solving a nasty economic problem without paying a penalty through lack of communication.

Simplification and Communication

Up to a point, simplified drafting can increase communication (between the engineer and the machinist, for example) by presenting the message in a clear-cut, non-cluttered fashion. To this degree everything but the draftsman's artistic temperament benefits. However, efforts to push simplified drafting too far cut down on clarifying detail, create problems in interpretation, and increase the possibility of error by the user. Therefore, a small saving of time in the drafting department can cause considerable trouble in the shop with the possibility of a serious net loss to the company.

Since many drafting departments are concerned with problems such as a shortage of well-trained personnel, not enough thought is given to their real function in a company—that of communication—when discussing simplified drafting. The problem of reducing and handling the drafting load within a company is often too severe to let anyone see the forest for the trees.

Nevertheless a serious economic problem is at the root of the drafting dilemma. Not until that economic problem is understood, and a totally new approach taken, can a long-range solution be sought. Simpli-

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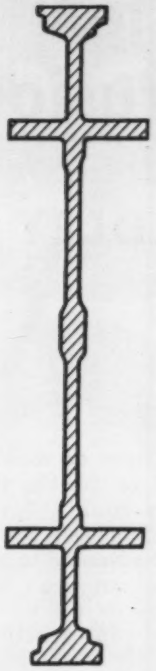
Metallurgical Memo from General Electric



This 32" diameter René 41 jet engine wheel is forged from a 450-lb. billet multiple. Note the cross section, showing the complexity of the forging.

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René 41 is just one of the high-purity General Electric vacuum-melted alloys that can be ordered in sheets, bars, billets, wire, or castings. Will one help solve a design problem for you? For more information—or for the assistance of a G-E engineer—write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Ave., Detroit 32, Michigan.*

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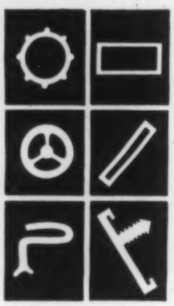

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Circle 596 on Page 19

fied drafting is approaching its limits, and it is still inadequate because it does not face the basic problem. However, recent developments in information-handling and photographic techniques point the way toward increasing the productivity of those responsible for communicating engineering information.

Methods of standardizing the views of common parts of schematics so that these can be quickly assembled on base drawings and photographed for reproduction can cut drawing time surprisingly. General Electric has developed a method of using "Symbolets"—small printed schematics of components used in assembling great systems. These "Symbolets" are held on a board by tiny magnets, their spacing is arranged, cabling is laid out, then a photograph is made. The negative is retouched and then enlarged on photosensitive transparent paper which becomes an original drawing.

Techniques such as this are not reserved for the so-called "standard industries." Even in the advanced research laboratories where claims are made that "nothing is standard," the engineers are working with standard "produced" parts and materials over 95 per cent of the time.

3-D Idea Exchange

Today, numerical control is being used to control the movements of machine tools and automatic assembly equipment. If design engineers and others would rearrange their thinking to approach a design problem utilizing the techniques of numerical control, they could deal in three dimensions directly in communicating information, rather than laboriously reducing ideas to two-dimensional paper before transmitting them.

If manufacturers will standardize parts and the information related to parts to a greater degree, there is no reason why information (including physical size and characteristics) cannot be coded on punched cards. The engineer—by defining closely his design parameters—can withdraw cards covering the parts and materials needed to solve his specific problems. Once the general outline of his design has been established, visual and numerical representations of the items used become immediately available. Work is being done on this procedure, but a lack of standardization among parts producers is hampering efforts.

Using a computer to arrange and record three-dimensional spacing, the elements of an accurate drawing can be created by the engineer as he checks out his design. This would be particularly useful in breadboarding electronic equipment. Going a step further, physical dimensions and other information can be coded in such a way that the drawing is not necessary except for reference. With the coming of the automatic factory, information concerning a design which the engineer has developed (recorded on tape in numerical form) can be fed directly to the computer and automatic control equipment running the factory. But just as the mathematical data needed to run the machines can be fed directly, so drafting machines can be made to translate the three-dimensional design data (through numerical control) into finished drawings.

These drawings, however, will be by-products and not the media of communication between originator and user. They will be kept as records.

The automation of drafting, however, will not eliminate drafting as an occupation any more than automation has eliminated any other occupation.

To solve the drafting problem, we will have to stop thinking in terms of drafting and attack the real problem, which is the communication of engineering information.

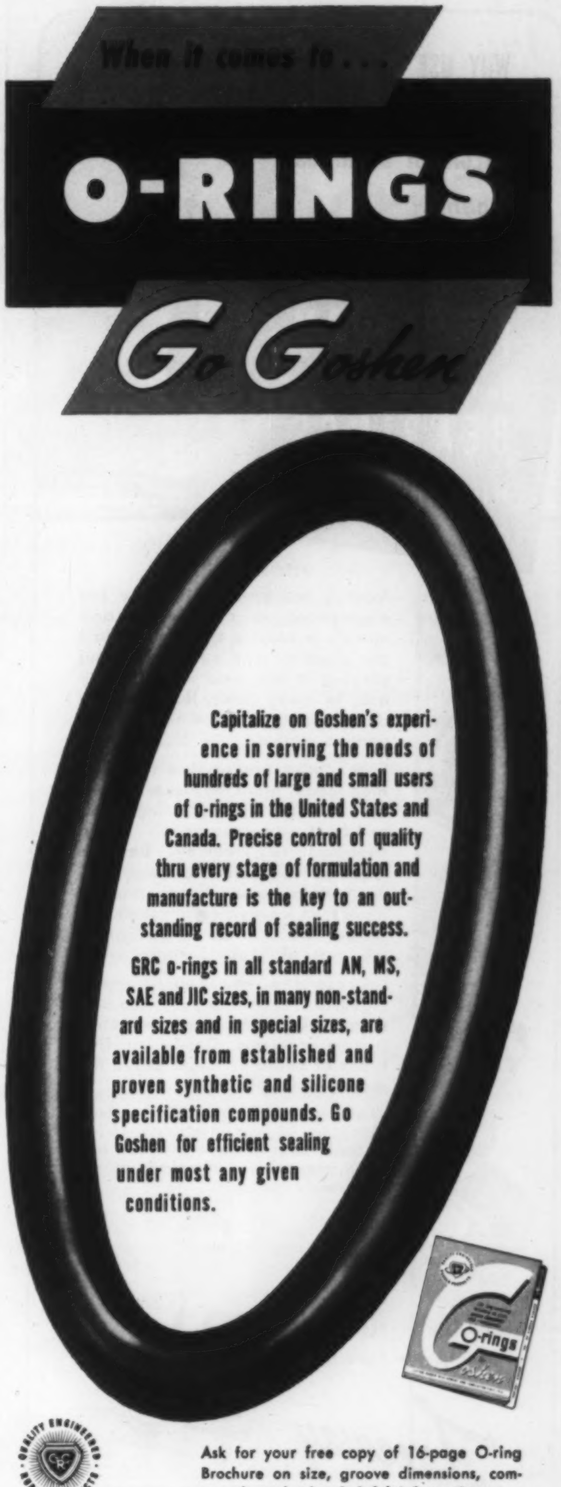
As a beginning, we can:

1. Investigate existing data handling techniques and encourage their refinements. Trends in methods of handling information in a more direct fashion should be explored. This involves studies in the theory of communication, logic and administration. A continuing study of this sort would enable a firm to use the latest tricks on the solution of the drafting problem.
2. Considering the company as an integrated whole, investigate the technical communication problem within it as a whole. Each business has peculiarities which must be understood, but basically the problem is one of getting information from the engineer's mind to the production machine with as little lost motion as possible. Through force of habit, the engineer often sets the information down in a form which is unusable for machine control. Hence, a draftsman has to interpret the information and set it down in a form understandable to a machine operator who translates the drawings into action. With a little more investigation and thought, the engineer will most likely find it more convenient to "speak" more directly to the machine. What steps in the communication chain can be simplified or eliminated will depend upon the existing method of handling information within a company.
3. Expand standardization. Standardization is fundamental to the efficient handling of information. Information on parts and materials, as well as their properties and characteristics, must be uniform and complete irrespective of manufacturer. And this information must be based on common standards so that engineers can define their needs in common terms. Standardization has to precede the communication and it must be done with imagination. In short, data must be reduced to its simplest elements and organized for more rapid utilization.

It may seem that a preoccupation with standardization is straying from the subject of communication since it precedes the design work, but this is not true. Just as the meaning of words has to be standardized before communication between individuals is possible, so must all the elements of the engineering message be standardized before they can be used effectively. Only thus can engineers be released from drudgery to deal with truly creative tasks.

If we can overcome our emotional habits, we might be able to accept the notion that drafting is a rather primitive and laborious method of communicating engineering information. Even if we cannot accept this view, we must admit that the creation of adequate drawings at a reasonable cost is difficult and that a new approach to the solution of the drafting problem is needed. Simplified drafting has not fully met the test.

—Gordon F. Shea
Litton Industries of Maryland
College Park, Md.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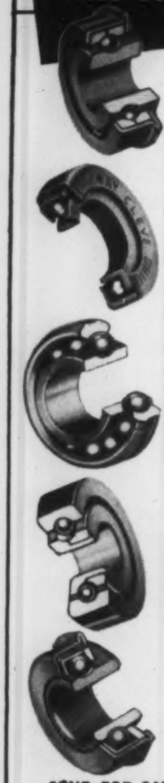

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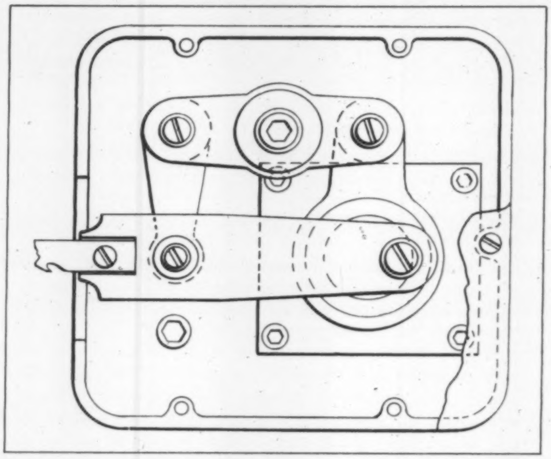
Patents

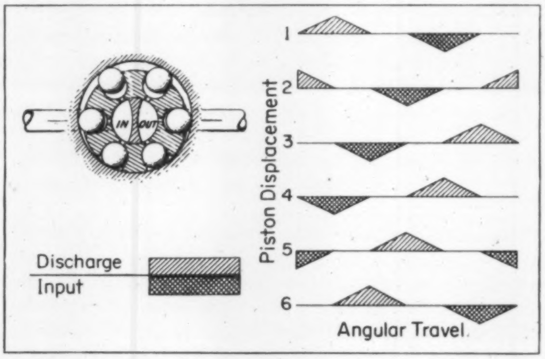
Rocking-Linkage Drive

A multiple-member linkage produces motion such that a saw blade, fixed to one member, engages a work piece in the cutting direction and clears the work piece in the opposite direction. Two points in the linkage are fixed: The center of a driving crank, having the form of an eccentric pin, and the center of a rocking link. *Patent 2,884,789 assigned to The Porter-Cable Machine Co., Syracuse, N. Y., by Lars Frostad.*



Pulsation-Free Pump

In a multiple-piston hydraulic pump, also useable as a motor, the interior contour of the casing is shaped to prevent damaging pulsations of flow which occur when pistons are passing from input action to discharge action, that is, during commutation. In this case, the pistons are spheres carried in a rotating ring bored to receive them. As the ring rotates about a



Circle 598 on Page 19

stationary pintle, centrifugal force moves the balls radially outward against the interior casing wall. Holes connect the ball chambers with inlet and discharge grooves in the pintle. The casing wall functions as a cam to assure constant uniform acceleration and deceleration in each piston cycle. Equal spacing of pistons balances their actions. *Patent* 2,882,831 *assigned to General Electric Co. by Tord Dannevig.*

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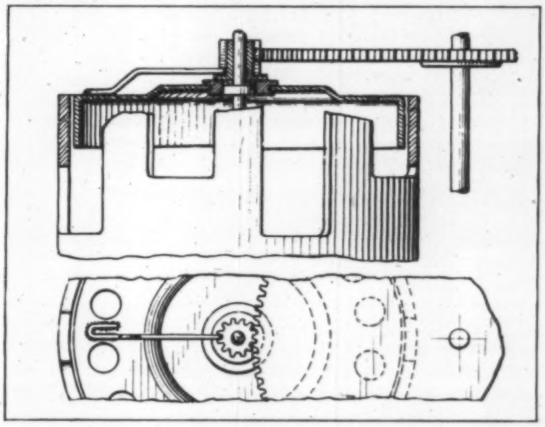
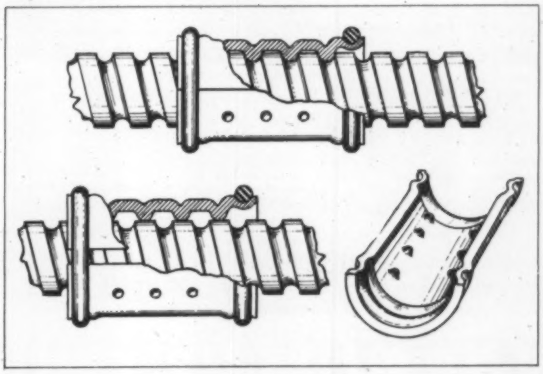


Expandable Load-Release Nut



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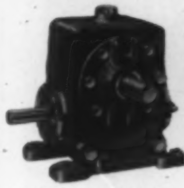

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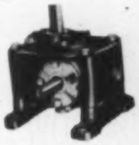
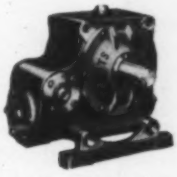
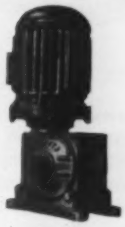


Vertical mounting

Inverted mounting



Double reduction worm gear



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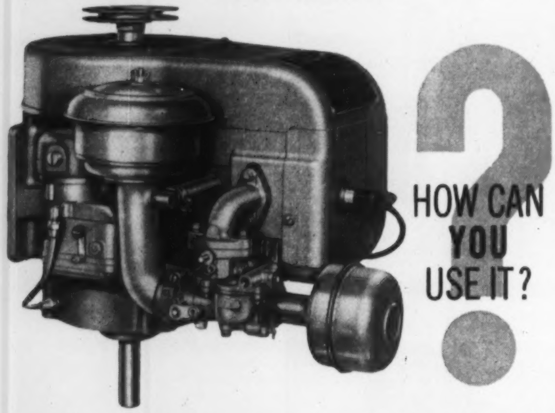

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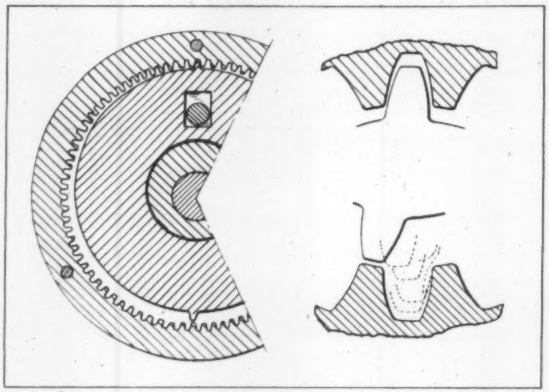
World's Largest Builders of Heavy-Duty Air-Cooled Engines
A9-6307

are formed from metal sheet stock and have detents projecting radially inward. Under normal load, the detents engage the helix of the screw. At overload, the detents ride over the helix. *Patent* 2,882,781 *assigned to Cleveland Pneumatic Industries Inc., Cleveland, by James T. Gates.*

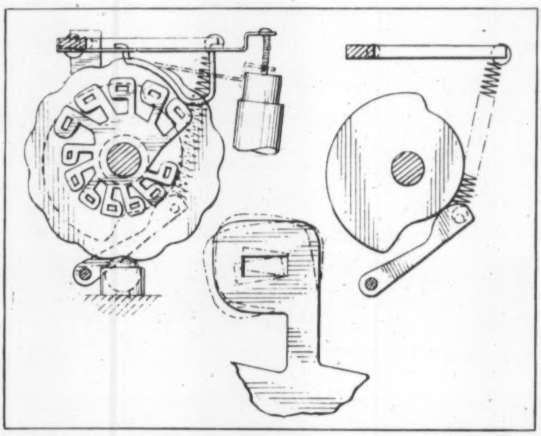
Cam-Driven Rotary Speed Changer

Very high ratios of input-to-output speeds are obtained by a cam-driven rotary speed changer. An eccentric circular cam is keyed to a central input shaft. The cam drives a circular follower enclosed by a stationary internal gear which is the housing of the assembly. As the follower is driven radially, two teeth on its periphery, slightly off a common diameter, alternately engage and disengage the teeth of the casing. This action rotates the follower once for input speed equal to the number of internal teeth. *Patent* 2,884,815 *assigned to Globe Industries Inc., Dayton, Ohio, by Paul R. Pittman Jr.*



Multiple Simultaneous Settings Mechanism

In a control assembly, a number of interdependent settings are made simultaneously by an equal number of adjustable cams fixed on a common shaft. The cams displace spring-loaded followers which determine the



TROMBETTA SOLENOID CORP.

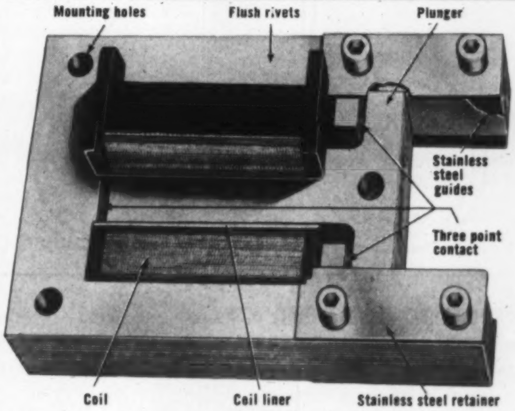
MILWAUKEE WISCONSIN
U.S.A
329 N. Milwaukee Street • Phone BRoadway 1-8347

NA-700 LINE OF SOLENOIDS

The ultimate design in
Guided T Plunger Solenoids

Patented March 10, 1959
Developed in 1952
Patent No. 2,877,390

WE DESIGNED THEM!
WE DEVELOPED THEM!!
WE PATENTED THEM!!!
THEY ARE OURS!!!!



No clatter! No chatter!!

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Positive three point contact
Heavy stainless steel guides

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Longest life expectancy; reliable operation throughout entire life; silent operation in sealed position; mountable in any position, at any angle; no heavy grease required to cover up poor design; no grunting when mounted horizontally.

AVAILABLE

In a multitude of standard sizes, pull or push type; also custom built to satisfy customer's requirements; also for OEM, and replacement trade.

TROMBETTA has the original solenoid.
Don't let anyone sell you imitations.
Request additional information.

"TROMBETTA"

is the answer to:

ALL SOLENOID QUESTIONS

Circle 601 on Page 19

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"Monoball"®

SELF-ALIGNING BEARINGS

ROD END TYPES
PATENTED U.S.A.
All World Rights Reserved
PLAIN TYPES

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

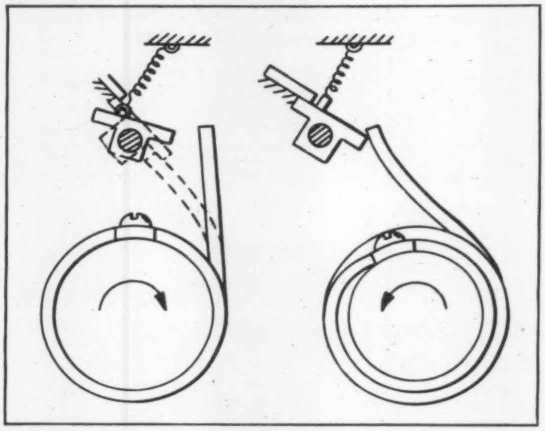
Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. **MD-M59**

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Circle 602 on Page 19

positions of an equal number of control members. The control cams are flat plates which carry a number of lobes on their peripheries. The shapes of the lobes enable them to be bent for fine adjustments. To facilitate bending, each lobe has a rectangular slot which can receive a screwdriver blade, for example. Torque required to rotate the common central shaft is equalized in all shaft positions by a single plate cam and a spring-loaded, pivoted follower. *Patent* 2,883,864 *assigned to Aladdin Industries Inc., Nashville, Tenn., by Francis G. Mason.*

Ratchet-Action Spring Clutch



When the driving shaft of a spring clutch is rotating in a driving direction, it tends to wrap the helical spring upon itself. The spring is designed strong enough to hold in reverse direction against unwinding action of the drive shaft. After limited reverse motion (one revolution or less as desired) a projection from the free end of the spring engages a dog, unwinding the spring enough to free the shaft. Irreversible ratchet action allows the spring projection to depress the dog in forward motion. *Patent* 2,883,022 *assigned to I-T-E Circuit Breaker Co., Philadelphia, by Challiss I. Clausing and Anthony P. Romano.*

One-Way Clutch

In a one-way clutch, the shapes of two concentric cage rings enable each to serve two functions: Contain gripping members, and provide plain bearing surfaces. Plane ends of the rings are unbroken surfaces. Between ends, spaced holes receive gripping members. Webs between the holes are shaped, in section, to tilt gripping members, promoting engagement. The same purpose is served by an annular coil spring which joins all gripping members. In the disengaged direction, cylindrical inner and outer edges of the cages function as journals. *Patent* 2,879,869 *assigned to Borg-Warner Corp., Chicago, by Adiel Y. Dodge.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commisioner of Patents, Washington 25, D. C.

CLOSED
1—Humphrey Valve shown for "normally closed" operation (cutaway).
OPEN
Exhaust Norm. Open
Input Norm. Closed
Del. to Cyl.
3 — Same valve, turned 90 degrees to show exhaust port through which "used" air is released.
2—In "open" position—(palm button depressed) air flows freely through wide ports into cylinder.
4—All Humphrey Valves incorporate this same principle—with choice of valve body styles for:
- Exterior mounting
- Insert for manifold
- Manifold-mounted

HUMPHREY "Quick-Dump" VALVES
OFFER *MORE* ON 2, 3, 4-WAY APPLICATIONS

- Pressures to 125 psi
- For Air, Gases, Water, Oil
- Dead Seal Shut-Off
- High Capacity Porting
- Cycling to 30,000/Hr.
- Extra Service Life
- For Original Equipment and Plant Use

ELECTRICALLY OPERATED
2-way and 3-way valves. Both one-coil "fail safe" and two-coil "momentary impulse" types.

MANUALLY OPERATED
2-way and 3-way finger-tip operation. A touch opens or closes. Many models — lever, cam, foot pedal, palm button, etc.

PILOT-OPERATED ELECTRIC VALVES
2-way and 3-way models, actuated by independent source of pressure. Two types: "fail safe" and "momentary impulse."

PILOT OPERATED VALVES
4-way 5-port shown (2, 3-way avail.) actuated by medium (gas or liquid) separate from medium being valved.

FULL ⅛", ¼", ½" CAPACITY THROUGHOUT—42 MODELS
Basically simpler, faster-operating, longer-lived control valves. For temperatures from —65 to 225° F. Many exclusive, better features for superior performance. Adopted by nationally known O.E.M. firms.
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Pneumatic-Hydraulic Valves and Devices

Circle 603 on Page 19

Stearns electro-magnetic miniature CLUTCHES

STYLE "SM"*

Now Available in 6 Standard Sizes

* *Stationary Magnet*

- Installation-Proved Reliability
- Wide Range of Size . . . from ⅞ in. to 4¼ in. Torque from 25 oz in. to 240 lb in.
- Heavy-Duty Construction
- Fast, Easy Installation
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- Moisture-, Corrosion-Resistant
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Circle 604 on Page 19

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TEFLON SEAL
PAT. PENDING

Saves hours in piping installations

Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

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TRU-SEAL DIVISION
FLICK-REEDY CORPORATION

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"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.

① Thread Tru-Seal on pipe or fitting as far as it will go hand tight.

②

Thread pipe or fitting 3 threads into port. Point in desired direction.

③ Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle 605 on Page 19

NEED A MOTOR WITH SPECIAL TORQUE?

If you've been tussling with torque, we can customize motors for you with the exact characteristics needed.

And we'll put that torque where you need it: starting, running, breakdown—any combination.

Typical applications in our extensive experience: submersible motors (up to 15 hp) with high-starting and special-overload torques; garage door openers with nominal torque values but instantly reversible; hoists with special high breakdown and starting torques.

You name the mechanical, physical, electrical and environmental conditions. J & H will match your design exactly. Our range is from ⅛ to 3 hp, except for submersible motors.

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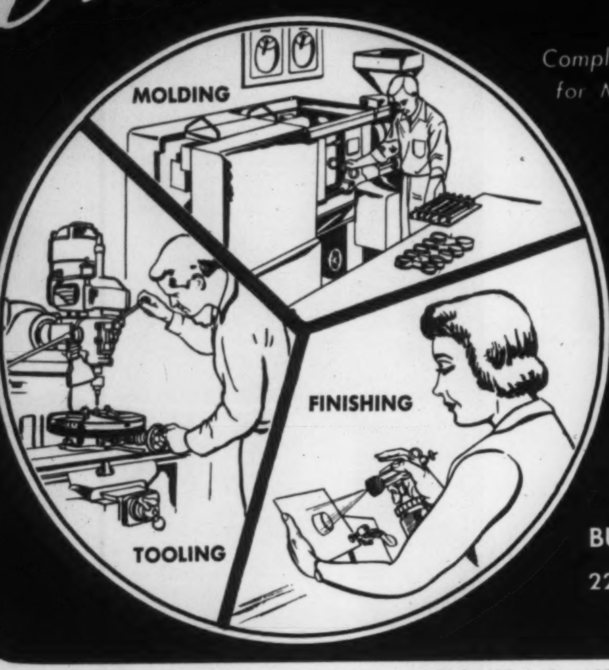

Complete Facilities for Molding by
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For over 27 years, Patent has continually produced the finest in plastic products. Modern facilities, combined with a thorough knowledge of plastic materials, have enabled Patent's customers to take advantage of the economics and physical properties of plastic materials.

Patent

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PHONE 2-9621

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BOWSER FLOW indicating DEVICES

Tell when liquids are moving, if quality is right, and indicate flow.

Fig. 55A
Flow Sight

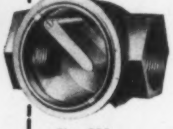

Fig. 811
Flow Indicator

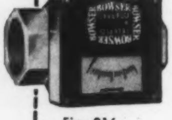

Fig. 816
Teleflow
Indicator

Plant and product engineers have relied on Bowser, liquid handling specialists since 1885, for prompt service. For sight glasses in single or double-window types, gravity or pressure models; or for electrical or mechanical indicators . . . and a full line of sight feed oilers.

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FLOW INDICATING DEVICES
SHOW WHAT GOES ON IN THE PIPE LINE

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MARKETING DIVISION

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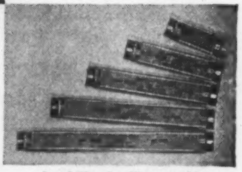
New
POWER RESISTORS
for FLIGHT USE

ELECTRO-FLEX

specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.



Insulation is silicone rubber— operable continuously at 450° F.
Mounting metal— Alclad aluminum.
Connection tabs— silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

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"FIRST with STANDARD ELEMENTS"

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No. 1

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IN DURABILITY

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BENDIX ELECTRIC FUEL PUMP FOR EVERY INDUSTRIAL USE

In every type of industrial application, the Bendix* Electric Fuel Pump has proved itself with outstanding performance under extremely adverse conditions. In tests conducted under U. S. military supervision, it has proved itself at temperatures ranging from 114° to −76° Fahrenheit. It's easy to install and service, has a built-in pressure release, pumps more gallons per hour and positively prevents vapor lock. It will outperform any other fuel pump anywhere near its price. Write for descriptive folder and specifications. *REG. U.S. PAT. OFF.

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ECLIPSE MACHINE DIVISION

Bendix
AVIATION CORPORATION

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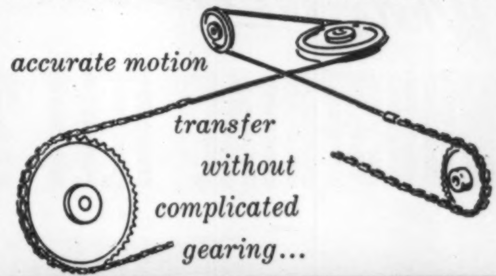

accurate motion transfer without complicated gearing...

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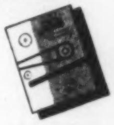
Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

NEW CATALOG



Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

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Sierra
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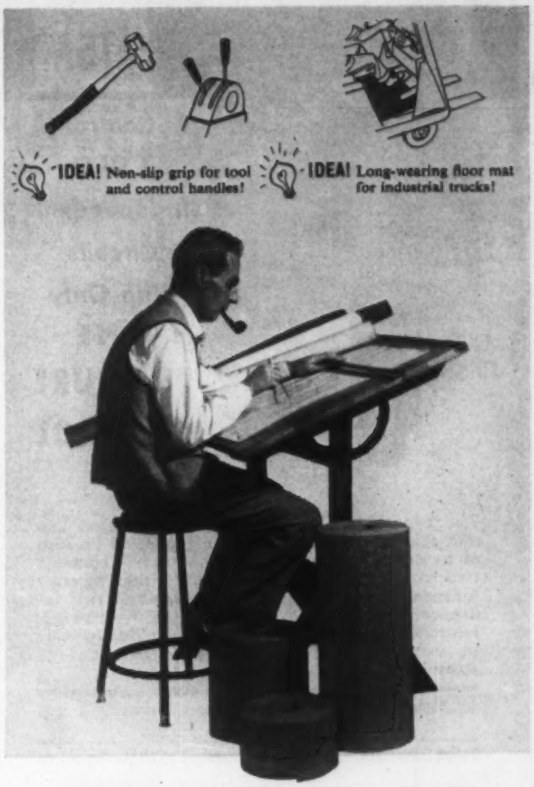
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IDEA! Long-wearing floor mat for industrial trucks!

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FUNCTIONAL! Textured "Scotch-Tred" surface has high capabilities in slip and skid elimination. Resilient under pressure . . . extra long-wearing . . . non-sparking. *Decorative!* Modern soft colors—beige, gray, black—harmonize with any scheme. *Versatile!* "Scotch-Tred" conforms smoothly to almost any surface; can be cut with scissors, knife, or die; pressure-sensitive adhesive sticks at a touch. Available in ¾" x 24" strips; 9" squares; bulk 96-foot rolls, from 4" to 36" wide. See Sweet's Product Design File insert $\frac{4b}{Mi}$.

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Please rush free sample of "SCOTCH-TRED".

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The Type J75A Dual Switch Pressure Control is a unit that has become increasingly popular because of its many unique features. This control contains two completely separate switches that operate independently of each other, controlling two independent circuits with extreme flexibility of switch arrangement. Pressure settings are individually made by independent adjustment screws that are easily accessible.

Adjustable Ranges	Various ranges between 0 and 250 psi.
Switch Differential	Approximately 5 to 10 psi dependent on model.
Switch Ratings	To 15 amps. at 115 or 230 volts A.C. Also available are 20 amps. A.C. D.C. switches also available.
Switch Types	Normally Open, Normally Closed or Double Throw — no neutral position.
Adjustments	Pressure settings individually made by independent adjustment screws located on top of switch bracket. Switches may be set together to simulate double pole circuitry or set apart to obtain independent operation.
Maximum Pressure	350 psi.
Electrical Connections	Lead wires attached to screw type terminals on switches.
Pressure Connection	Via a 1/8" male NPT connection.
Mounting	Via pressure connection.
Bellows Material	Brass or monel.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Complete data is available for the J75A as well as for all standard UE controls.*

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83 SCHOOL STREET, WATERTOWN MASS.

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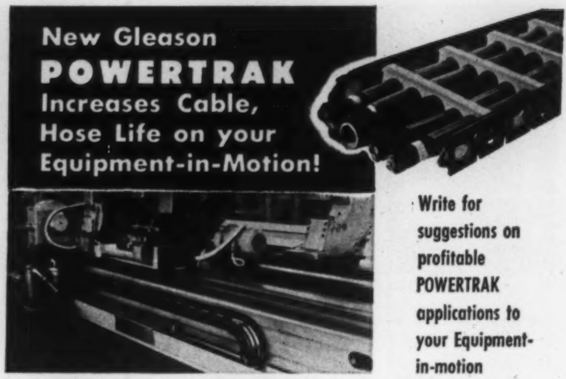
New Gleason POWERTRAK Increases Cable, Hose Life on your Equipment-in-Motion!



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Your equipment will benefit with POWERTRAK—amazing German invention for carrying power cable or hose to and with equipment in motion. Offers many advantages on machine tools, lathes, grinders, planers, presses, cranes and others. Protects power cables, oil, gas, and air hoses against wear from bending, crushing, abrasion, friction, pulling stresses and strains. Avoids machine downtime and cable or hose replacement expense.

POWERTRAK saves space, permits more flexibility in machine design. Handles multiple cable and hose up to 2½" diameter, up to 70 feet of travel, at moving speeds up to 300 feet per minute.

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TAKE-UP REEL HEADQUARTERS FOR ALL INDUSTRY

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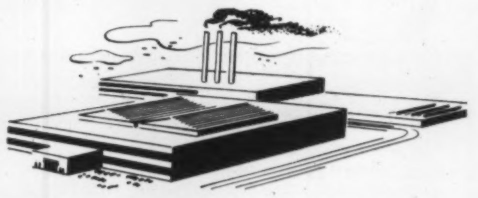

- **NOW!** Synthetic Fiber Felts and Wool Felts designed for exacting, special applications!
- **NOW!** Available CUT to meet your specifications!
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FREE Folder of samples and applications of Industrial Felt. Write for Booklet K-4.

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Circle 615 on Page 19

in Wheels, too...

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USE DUAL **ALLIED** WHEELS

In Place of ONE Larger, Expensive Wheel!

Gain These Advantages:

- **LOWER COST**—Reduce wheel cost! Buy Dual wheels for less than one single conventional type!
- **GREATER FLOTATION**—More tire surface on the ground. Spreads load suspension!
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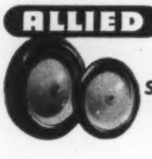

STOCK SIZES, TYPES — Or CUSTOM BUILT!

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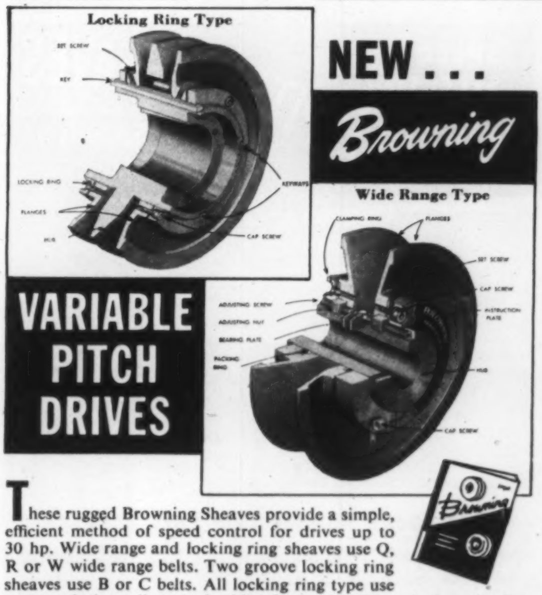

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These rugged Browning Sheaves provide a simple, efficient method of speed control for drives up to 30 hp. Wide range and locking ring sheaves use Q, R or W wide range belts. Two groove locking ring sheaves use B or C belts. All locking ring type use same exclusive split taper bushing featured in Browning's entire line of V-drives, chain drives, couplings and paper pulleys. Details in illustrated catalog V-183. Ask your Browning distributor for free copy, or write **Browning Manufacturing Company, Maysville, Kentucky.**

Browning POWER TRANSMISSION EQUIPMENT

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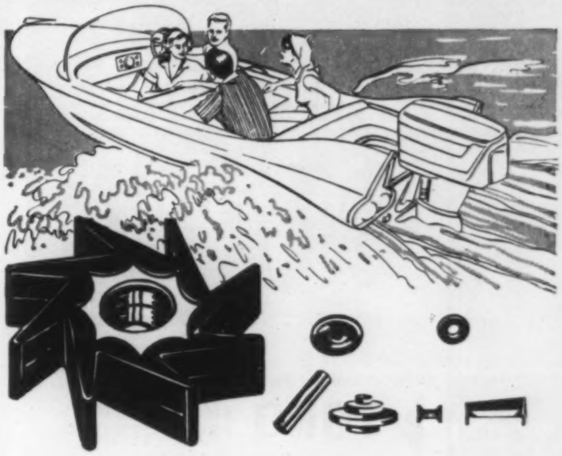
EXCLUSIVE INJECTION MOLDING for CUSTOM RUBBER PARTS



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THERE ARE NO OTHER SPEED DETECTING SWITCHES LIKE THE TORQ SYNPROTEX

TYPE I: (AUTOMATIC) GOVERNS NARROW SPEED BAND such as required on computers, series wound motors, generators . . .

TYPE II: (AUTOMATIC) DETECTS HIGH AND LOW LIMITS OVER WIDE SPEED BAND. Cuts out motor starting windings, protects furnace and electronic cooling blowers against over and under speed, maintains proper speeds of inter-related equipment, sequences equipment operations . . .

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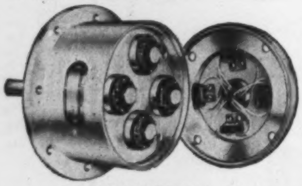
TYPE IV: HOUSED SWITCHES. Permits independent mountings, internally or externally, without design change. Standard housings accept any number of separate switches of any typ~ or combinations. Custom housings on order.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SINGLE DETECTOR

Tolerances to ¼ of 1% *Guaranteed Uniformity*
Standards Furnished for Speeds From 0 to 15,000

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The Mayline linoleum covered all steel top provides the finest in drawing surfaces. It is resilient yet firm. It is ideal for both pencil and ink drawings, and it never warps.

Consider this fine top when you purchase either a 4-Post drafting table or the May-O-Matic table. Top is completely described in Catalog 10 and Folder S-22. Your copies are available on request.

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Sheboygan, Wisconsin

MAYLINE

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- For inside and outside application. All sizes. Immediate delivery.

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

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METAL Caps to cover AN & SAE threads

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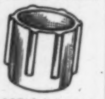
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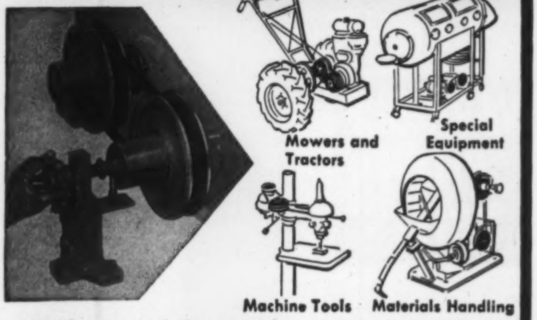

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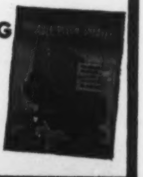

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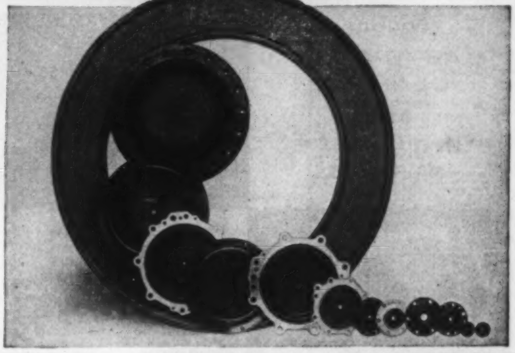

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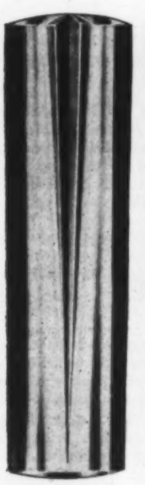

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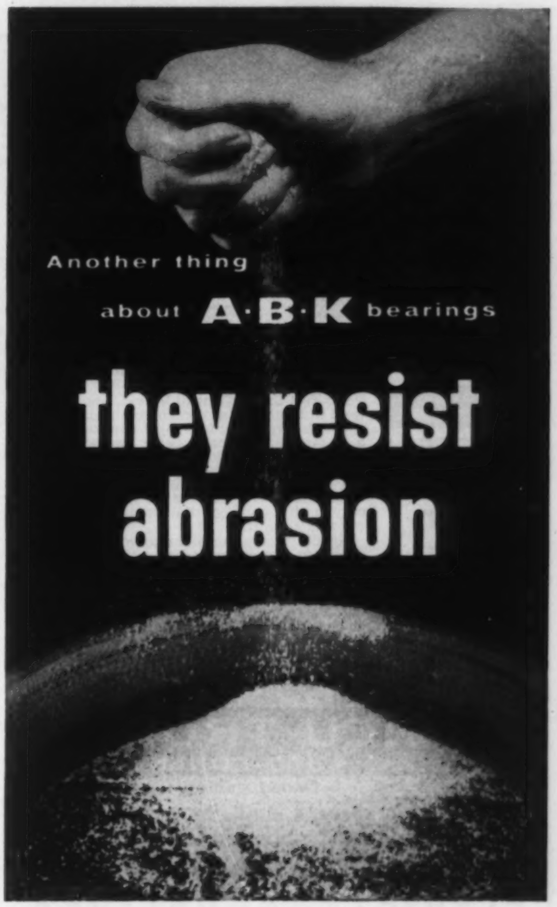

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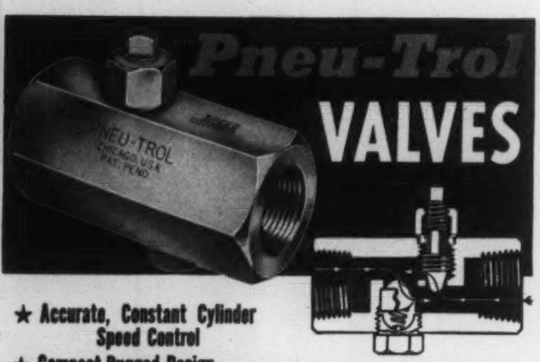

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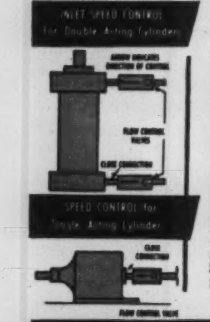
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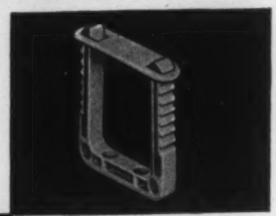

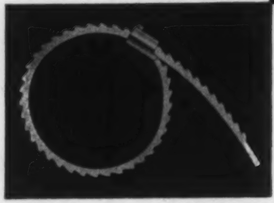

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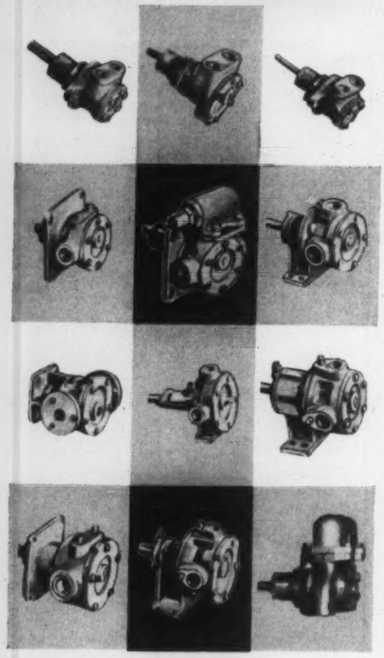

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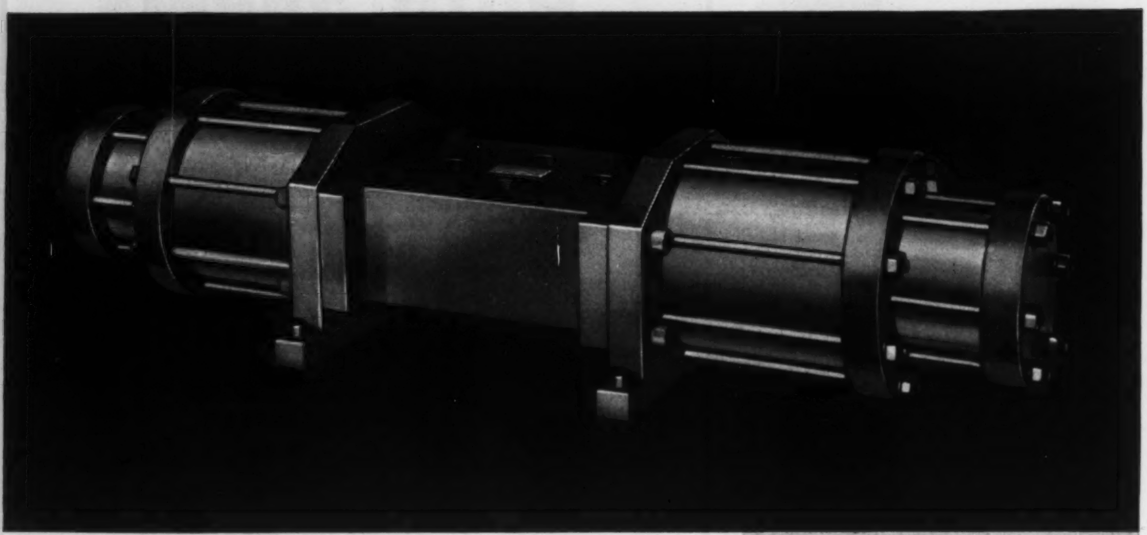

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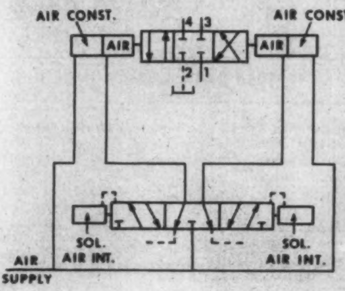

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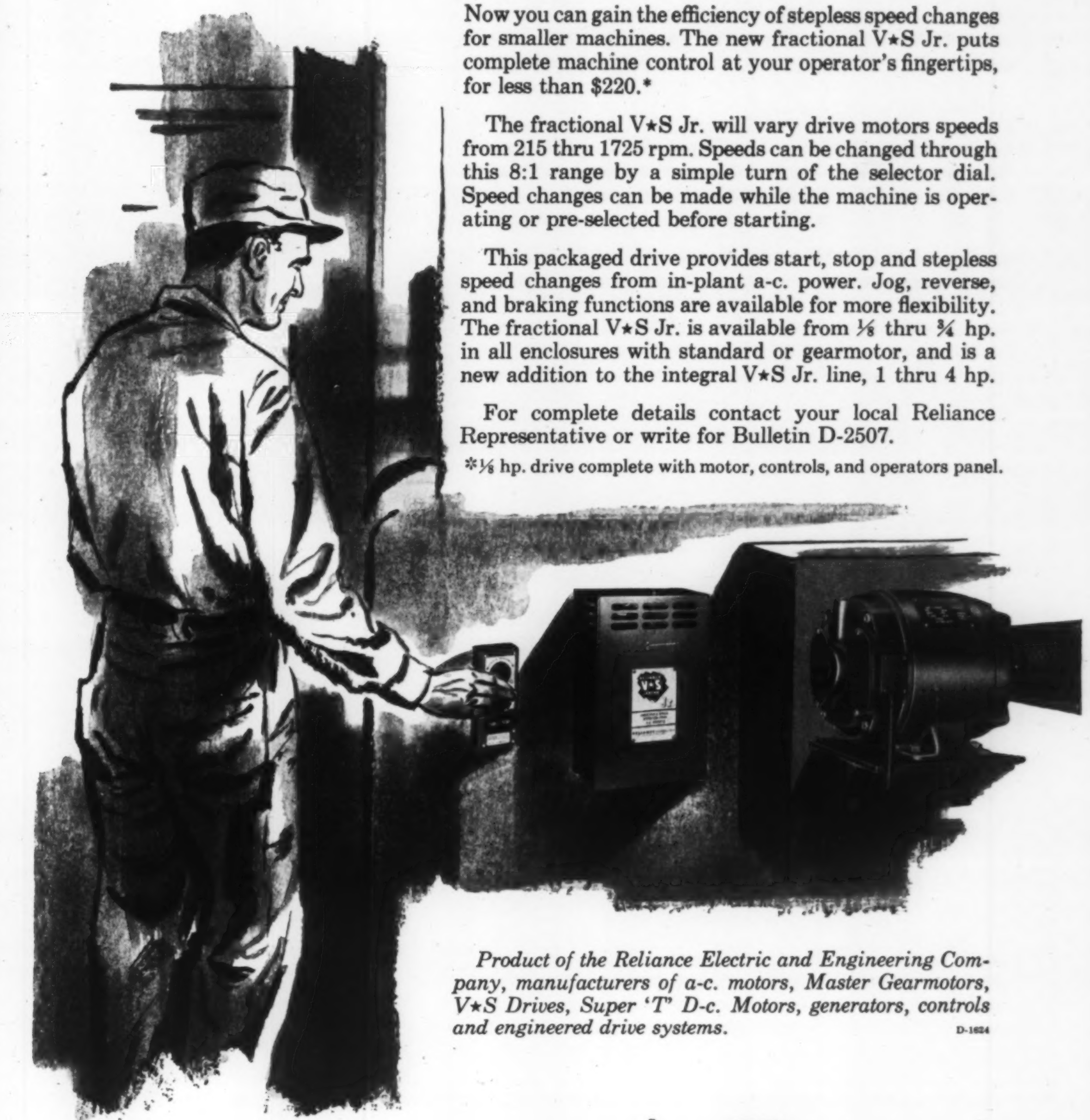

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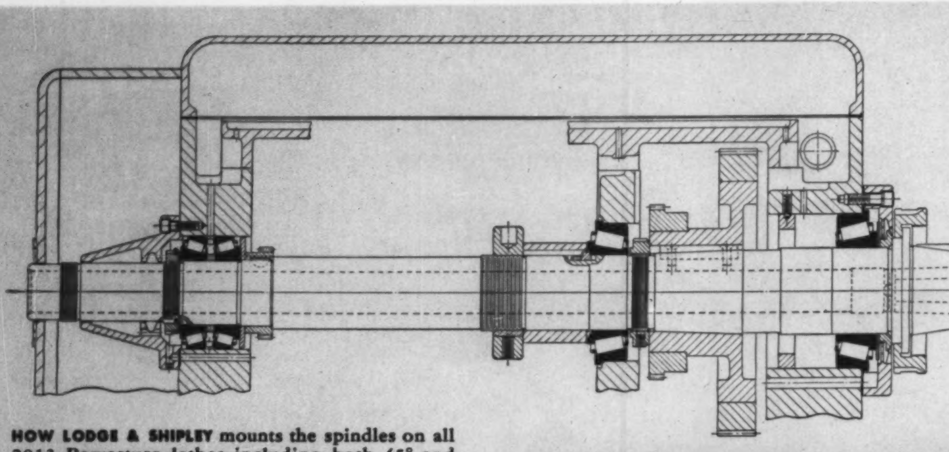

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How spindle is held rigid. Timken bearings hold the spindle in positive alignment. They take *both* radial and thrust loads in any combination, because of their tapered design. And because of full line contact between rollers and races, Timken bearings have extra load-carrying capacity.

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How friction is virtually eliminated. Timken bearings are geometrically designed to roll true. And they're precision-made to live up to their design. They run smoother—last longer.

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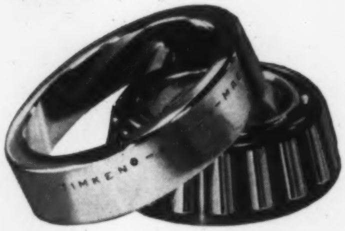

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